THE AMERICAN JOURNAL OF ROENTGENOLOGY, RADIUM THERAPY AND NUCLEAR MEDICINE

VOL. 77 APRIL, 1957 NO. 4

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THE AMERICAN JOURNAL OF ROENTGENOLOGY
RADIUM THERAPY AND NUCLEAR MEDICINE

VOL. 77 APRIL, 1957 No. 4

SECRETORY SIALOGRAPHY IN DISEASES OF THE MAJOR SALIVARY GLANDS*

By PHILIP RUBIN, M.D., *and* JOHN F. HOLT, M.D.
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SINCE Bársony[3] introduced the technique of injecting radiopaque media into the duct system of the salivary glands in 1925, few changes[6,9,21,23,35] have been suggested in the procedure. Sialography is akin to many other studies in diagnostic radiology in which invisible lumina are rendered opaque by the introduction of the appropriate contrast material. The emptying phase, as shown by postevacuation roentgenograms of the colon and post-fat feeding roentenograms of the gallbladder, has been of as much diagnostic significance as the filling phase of these organs, and therefore it was felt that similar studies in the salivary glands might prove valuable. Evacuation of the radiopaque substance is facilitated by the flow of saliva, induced by the reflex chemical stimulation of the gland. This new modification, termed "secretory sialography"[31,32] has been used to investigate a broad range of clinical cases and establish criteria for roentgen studies of the salivary glands in health and disease. In this process, certain patterns have been noted which aid in differentiating normal and pathologic conditions.

Technique of Injection. Under usual conditions, the time required for average sialography is about twenty minutes. The equipment includes a set of Williams olive-tipped lacrimal probes, Bowman plain-tipped lacrimal probes, a 2 ml. hypodermic syringe, and polyethylene catheter No. 60 (equivalent to a 21-guage hypodermic needle). The patient is placed in the sitting position; illumination preferably should come from a head-mirror lighted directly or indirectly. The orifice of Stensen's duct is in the papilla of the buccal mucous membrane opposite the second molar tooth, while that of Wharton's duct is found on the floor of the mouth on either side of the midline at the base of the frenulum of the tongue. A punctate director is inserted into the mouth of Stensen's duct, then dilatation is accomplished with the olive-tipped probes. In order to complete the dilatation, probes in sizes 1 through 4 are inserted up to the border of the masseter muscle. A polyethylene catheter (with a fine wire stylus for rigidity) sterilized in 1:500 aqueous benzalkonium chloride for at least twenty-four hours, is then inserted into the duct for a distance of 3 to 4 cm.

A. Principles of the Filling Phase. If

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relatively painless and satisfactory sialography is to be accomplished, three basic principles must be respected.

1. *No preconceived or precalculated amount of contrast material should be injected into a salivary gland. The amount used should be governed by the production of pain.* The injection should be carried out slowly. In the majority of patients, a definite pressure sensation occurs when 0.25 ml. of contrast medium has been injected into either the submaxillary or parotid duct. The end point of the injection is the moment when definite pain occurs. The pain produced is probably due to sudden capsular distention and is akin to salivary gland pain produced in acute inflammatory or obstructive processes. Therefore, the injection should be slow and controlled. As stated previously, the amount which can be injected into normal glands may vary between 0.5 cc. to 1.0 cc. In diseased states there is a wider range in the quantity which must be used to obtain a good sialogram. In infectious and obstructive conditions producing dilatation of the duct system, quantities up to 2.0 cc. have been used. In neoplastic disease the required quantity is usually that required for a normal gland, or even less since the gland parenchyma may be replaced by the neoplasm.

2. *The ideally injected gland shows filling of intercalary ducts and minimal delineation of the acini in the roentgenogram* (Fig. 1*A*). Overinjection advocated by some authors will lead to rupture of acinar cells and obscuration of the ducts. Quantities greater than 2 cc., even in disease, are rarely neces-

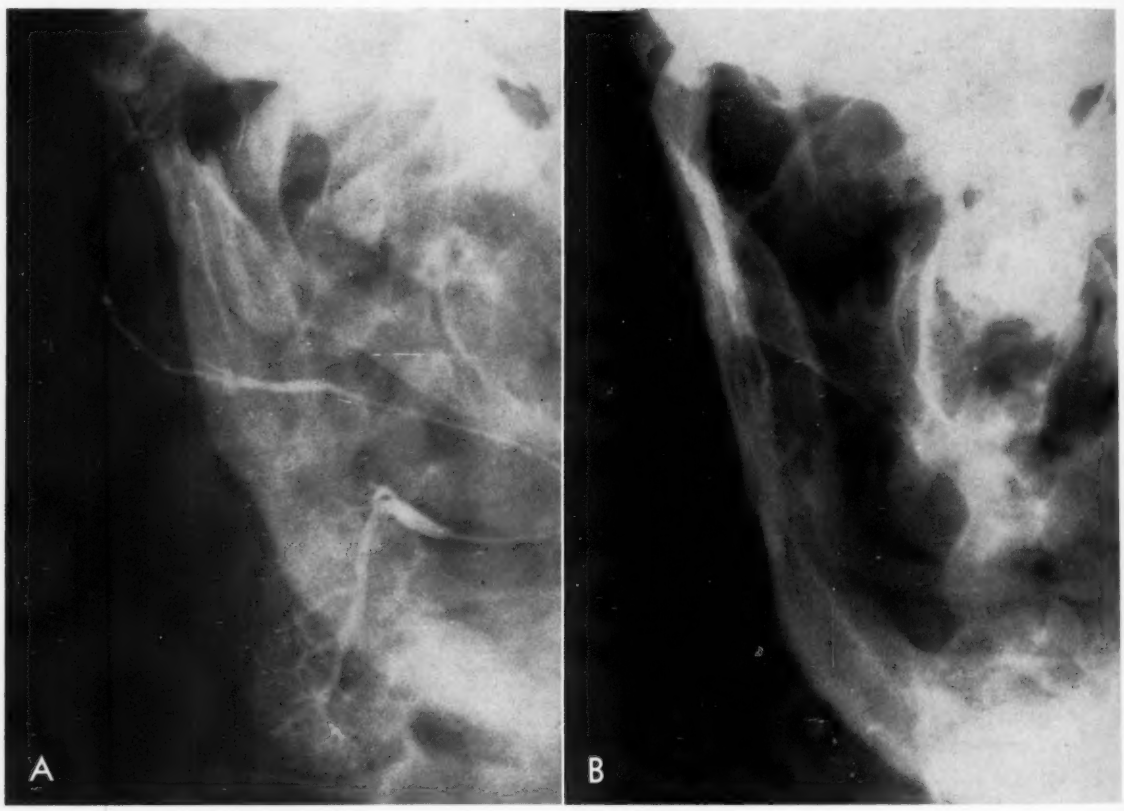

Fig. 1. Simultaneous injections of two normal salivary glands: (*A*) In the filling stage note the diffusion of contrast medium into the acini of the submaxillary gland, as opposed to the parotid because of difference in injection technique and in the pain threshold. (*B*) Postevacuation film shows no residual in the parotid gland, but a fine cloud of contrast material in the submaxillary gland represents acinar fill and will disappear in one hour.

sary for diagnostic purposes and are not tolerated well by the patient. The cumulus cloud effect of extensive acinar filling is as undesirable in sialography as is alveolar filling in bronchography.

3. *A closed system should be employed as opposed to an open system of injection which implies that the full amount of contrast material injected is kept in the system.* To keep the system closed, the polyethylene catheter is plugged when the injection is finished by means of a wooden stopper (a toothpick). In the open method, a blunt edge needle is employed which is removed from the duct upon completion of the injection, allowing the contrast material to escape from the duct while the films are exposed. Fractionated injection studies indicate that one-half to one-third of the injected radiopaque medium is lost when the open system is used.

B. Principles of the Emptying Phase. Roentgenographic study of the emptying of the contrast material from the salivary glands has been neglected. The misconception perpetuated by repetition in the literature[4,21,34] is that "lipiodol empties from the gland in one to three days in the normal. When greater quantities of contrast medium are used or when repeated studies are done, a residual can be seen on films five to fifteen days later." These statements appear to be incompatible with the physiologic fact that the average salivary gland (parotid or submaxillary) secretes 25–30 cc. of saliva per hour by continuous stimulation, as in mastication of food. If stimulation of the gland can produce such a profuse secretion, it would appear unlikely that it would be unable to wash a few cubic centimeters of contrast material from its duct system. A review of the basic physiology of secretion of the salivary glands was undertaken to determine if any information so derived could be applied to sialography. In the normal life of the animal, the secretion of saliva is initiated reflexly either by inherent or by acquired (conditioned) stimulation. In the first instance materials placed in the mouth call forth, after a short latent period (2 to 3 seconds), a secretion of saliva which varies in quantity and quality with the physical nature of the stimulating substance. The effects which sensations of taste produce upon secretion of saliva are well known. Usually the most palatable substances are the most potent salivary stimulants; however, substances upleasant of the taste, such as strong organic acids, are also potent sialogogues.

In applying the above physiologic phenomena to sialography, the patient is instructed to suck on a lemon, as a source of citric acid, for one minute. Stimulants such as minted gum, candy, or diluted vinegar also may be used effectively. Thus, as the gland is stimulated the contrast material is washed from the duct system, after which the patient rinses his mouth to remove the radiopaque substance prior to postevacuation roentgenography. In a study of more than twenty-five normal galnds, all have emptied within five minutes if properly injected (Fig. 1*B*). Studies made with rapid changing of films show that the gland empties completely within the first minute after lemon stimulation. Occasionally, if some acinar filling occurs, a faint cloud of contrast material outlines the gland in the five minute post-stimulation film (Fig. 1*B*). However, this cloud is usually absent on the one hour film and has disappeared on the 24 hour post-stimulation film.

Roentgenographic Technique. The films are exposed with the patient in the horizontal position on a Potter-Bucky table, using the technique for routine skull examination. For both parotid and submaxillary sialograms, posteroanterior and lateral films are used in the preinjection and injection phases and five minutes after stimulation. For the posteroanterior projection, the Grainger projection is employed. The deep lobe of the parotid gland is best evaluated on a reversed basilar projection of the skull. Stereoscopic films of the injection phase are preferred. If the poststimulation films show retention of contrast medium,

films are made again after one hour and twenty-four hours.

In the present study we have employed the following contrast materials: (1) lipiodol—40 per cent iodine in stable iodide compound in poppy seed oil; (2) iodochloral—27 per cent iodine in organic combination in a refined peanut oil; and (3) pantopaque—30 per cent iodine in an iodized, phenyl substituted acid derivative: ethyl iodophenylundecylate. The use of pantopaque is preferred because it has fulfilled most satisfactorily the criteria elaborated by Neustaedter and co-workers[19] for the ideal radiopaque mixture. It is of lower viscosity than the other materials and thus provides for ease and control of injection. The low surface tension of pantopaque permits ready diffusibility and greater penetration of the finer ducts under low injection pressures. In diseased glands, pantopaque tends to intermix with retained secretions rather than to form droplets and thereby create confusing shadows. In addition, its lower viscosity means less surface resistance and increased facility of excretion. This is of considerable importance in disease states where the secretory function of the gland is impaired.

The nonirritability and radiopacity of the above listed contrast materials are about equal in sialography. The production of pain as well as the pathologic changes are due to overinjection and retention. Both poppy seed oil (the vehicle of lipiodol) and peanut oil (the vehicle of iodochloral) have been shown by Epsteen and Bendix[8] to produce marked foreign body reaction, obliteration of ducts, round cell infiltration, and areas of focal necrosis after injection into salivary glands of dogs. However, if the gland is properly injected and upon immediate stimulation empties all of the contrast medium, it is unlikely that such unfavorable reactions will occur in normal glands.

Material. The technique of secretory sialography has been applied to various patients with swelling of the major salivary glands. This report is based upon the analysis of 100 cases in which more than 200 sialograms have been done. Correlation of clinical, pathologic, and sialographic observations has been stressed.

Table I

Number and Type of Patients	July 1953–June 1955
I. Normal	25
II. Inflammatory	
A. Chronic Obstructive Sialodochiectasis	24
1. Calculi (18)	
2. Strictures (6)	
B. Chronic Nonobstructive Sialectasis	21
1. Recurrent sialadenitis in children (5)	
2. Recurrent pyogenic parotitis (2)	
3. Sjögren's syndrome (10)	
4. Mikulicz's disease (3)	
III. Tumors	
A. Extrinsic	12
B. Intrinsic	18
1. Encapsulated, cellular (14)	
2. Encapsulated, cystic (2)	
3. Invasive (2)	
Total	100

I. Inflammatory Diseases of the Salivary Glands

A. Acute: Acute inflammatory diseases of the parotid or submaxillary gland seldom are problems in differential diagnosis. The most frequent infectious agent is the virus of mumps which may cause swelling of any or all of the major salivary glands. Unlike nonspecific acute inflammatory parotitis, mumps is interstitial and is not an acinar infection. Acute suppurative parotitis leading to abscesses occurs in acutely ill patients following major pelvic or abdominal surgery. Dehydration, oral sepsis and trauma are often associated, and on palpation the gland may be tender, swollen, and fluctuant. Sialography is contraindicated in all acute inflammatory diseases, since instrumentation and injec-

tion of foreign material into the duct system is deleterious.

B. Chronic: Chronic non-neoplastic swellings of the major salivary glands are due to various etiologic factors and are a constant cause of consternation among physicians endeavoring to arrive at the proper diagnosis. Among the causes listed in the literature are: (1) chronic recurrent sialodochoparotitis; (2) calculi and foreign bodies in the ducts; (3) specific infections as tuberculosis and actinomycosis; (4) Mikulicz's disease; (5) Sjögren's disease or the "sicca syndrome"; (6) Mikulicz's syndrome (lymphoblastoma, Boeck's sarcoid, gout); (7) hereditary familial hyperplasia; (8) hyperplasia associated with endocrine changes (menstrual cycle); (9) post-mumps sialadenitis; (10) "salivary retention" in the newborn; (11) drug intoxication such as lead, iodine, copper and opium; (12) allergy; (13) parotid swelling associated with hypertrophy of the masseter muscle; (14) strictures of the orifice; and (15) traumatic lesions.

This long list prompts one to seek a simpler classification to correlate the sialograms with the clinical findings. It is therefore proposed that chronic enlargements of the salivary glands be divided into two general groups on the basis of findings on sialography: (1) Chronic obstructive sialodochiectasis (in which the abnormalities seen are primarily in the main duct) and (2) chronic nonobstructive sialodochiectasis (in which the abnormalities seen are mainly in the peripheral ducts).

1. *Chronic Obstructive Sialodochiectasis.* There appears to be a fundamental difference between the pathogenesis of parotid and submaxillary gland swellings and the resultant sialographic pattern. Infection of the submaxillary gland is usually associated with calculi whereas parotitis is more commonly nonobstructive. This is readily appreciated by the frequent sialographic finding of dilatation of Wharton's duct and its primary divisions in contrast to the rarity of peripheral duct dilatation. There are two main subdivisions of obstructive salivary gland disease: (a) calculi and (b) strictures.

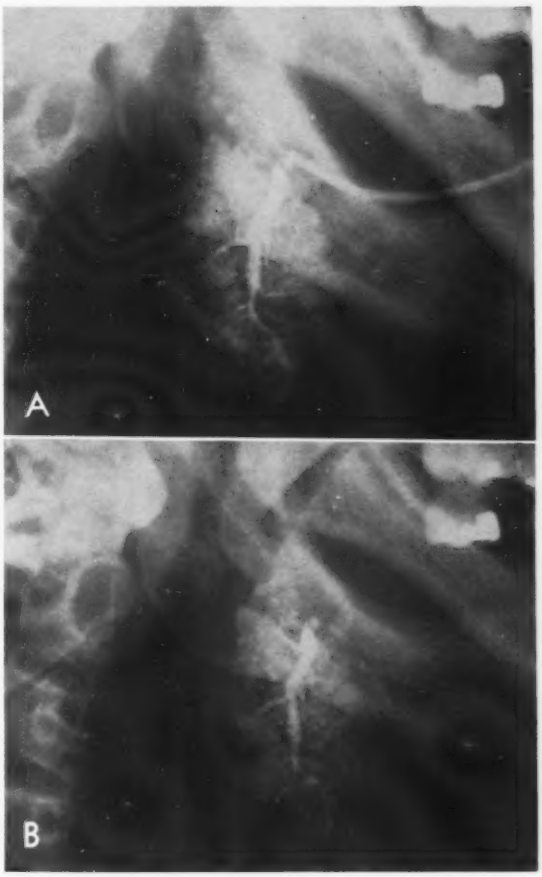

FIG. 2. Submaxillary calculus: (*A*) In the filling phase the calculus at the hilum of the gland is dislodged into the proximally dilated duct. (*B*) Following stimulation, the salivary flow forces the stone into the narrower distal portion of Wharton's duct, acting as a check-valve to retain the pantopaque in the gland.

a. Calculi. According to New and Harper[20] 92.9 per cent of 70 cases of salivary gland calculi occurred in the submaxillary gland, but Wakeley's[41] figure of 3.2 per cent incidence is a more generally accepted one. The clinical symptoms are related to the size of the calculus, the degree of obstruction produced, and associated secondary infection. Small salivary calculi (less than 3 mm. in diameter) are nonobstructive since they are smaller than the lumen of the main duct. When the salivary calculus exceeds 3 mm. in size, obstruction can occur. The patient generally complains

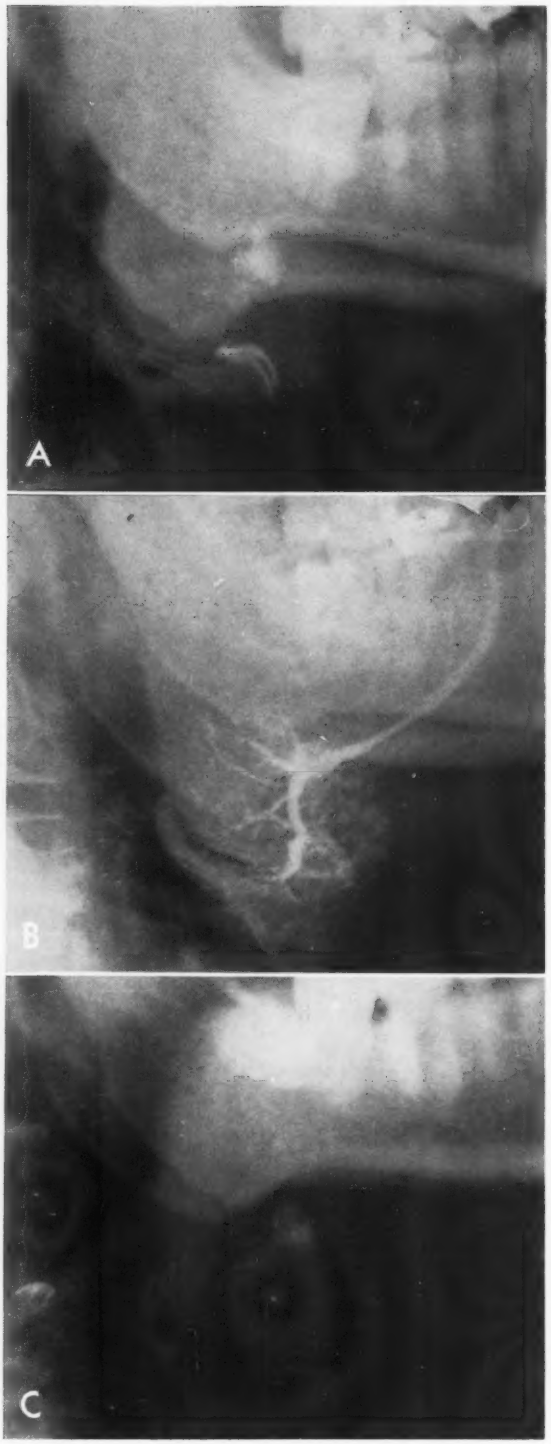

Fig. 3. Submaxillary calculus: (*A*) In the preliminary film, a large calcified calculus is seen at the angle of the mandible. (*B*) Following injection of the duct system with pantopaque, the glandular architecture appears to be intact. The moderate dilatation of the main duct distal to the calculus and the minimal atrophy of the peripheral branches suggest that the stone has partially eroded Wharton's duct and is sitting in a diverticulum, causing only partial obstruction to salivary flow. (*C*) In the postevacuation film, little contrast material is retained indicating that the glandular parenchyma is functioning. The gland therefore was not sacrificed and calculus was removed via an intraoral approach.

of pain and swelling, which is associated with meals and is due to the sudden capsular distention resulting from blockage of salivary flow. Total obstruction of long duration may lead to pressure atrophy of the glandular parenchyma.

Frequently, there is associated infection due to stasis and acute exacerbations, characterized by swelling, pain and fever which in the parotid gland may be indistinguishable from recurrent nonobstructive parotitis. At times suppuration and abscess formation have been noted. Calculi that have eroded through the wall of the main duct or one of its tributaries and have become lodged in the gland substance are prone to produce chronic infectious granulomas which in themselves cause continued suppuration and further duct obstruction.

b. Strictures. Simple duct obstruction, according to Rose,[29] is a common cause of recurrent parotitis. This author describes two types of duct obstruction which are dependent on a similar mechanism. These may be divided anatomically into the papillary and buccal varieties. Papillary duct obstruction is due to trauma to the papilla of Stensen's duct by movement of ill-fitting dentures. Also, a buccal mucositis associated with injury to the papilla during vigorous mastication in patients with masseter muscle hypertrophy may result in stricture formation. When the original inflammation has subsided, fibrosis may develop at the duct orifice and stenosis ensue. Following severe acute pyogenic infections, particularly staphylococcal and pneumococcal parotitis, multiple strictures of Stensen's or Wharton's duct may occur.

SIALOGRAMS OF CHRONIC OBSTRUCTIVE SIALODOCHIECTASIS

Scout Films. The most common cause of obstruction to salivary flow are calculi, which in the majority of cases are readily identified on preliminary films if calcified (Fig. 3*A* and 4*A*). Occasionally, a calcified calculus may not be recognized due to superimposition in routine views of the stone on skull structures. Approximately 20 per cent of calculi are nonopaque in the submaxillary gland and this figure is doubled in parotid calculi.

Filling Phase. Although the most important finding is dilatation of the main duct (Wharton's or Stensen's duct) and its primary and secondary ramifications, it should be recognized that small calculi (1–3 mm.) are usually nonobstructive and radiolucent. These small calculi are easily overlooked since they may be mistaken for injected air bubbles particularly when associated with larger nonopaque calculi.

If the main duct is dilated throughout, a history of repeated episodes of passage of stones usually can be elicited. Dilatation occurs distal to the stone which can be forced back into the widened duct lumen upon retrograde injection of contrast medium and permits visualization of the peripheral ducts (Fig. 2*A*). In early cases without evidence of infection, the peripheral

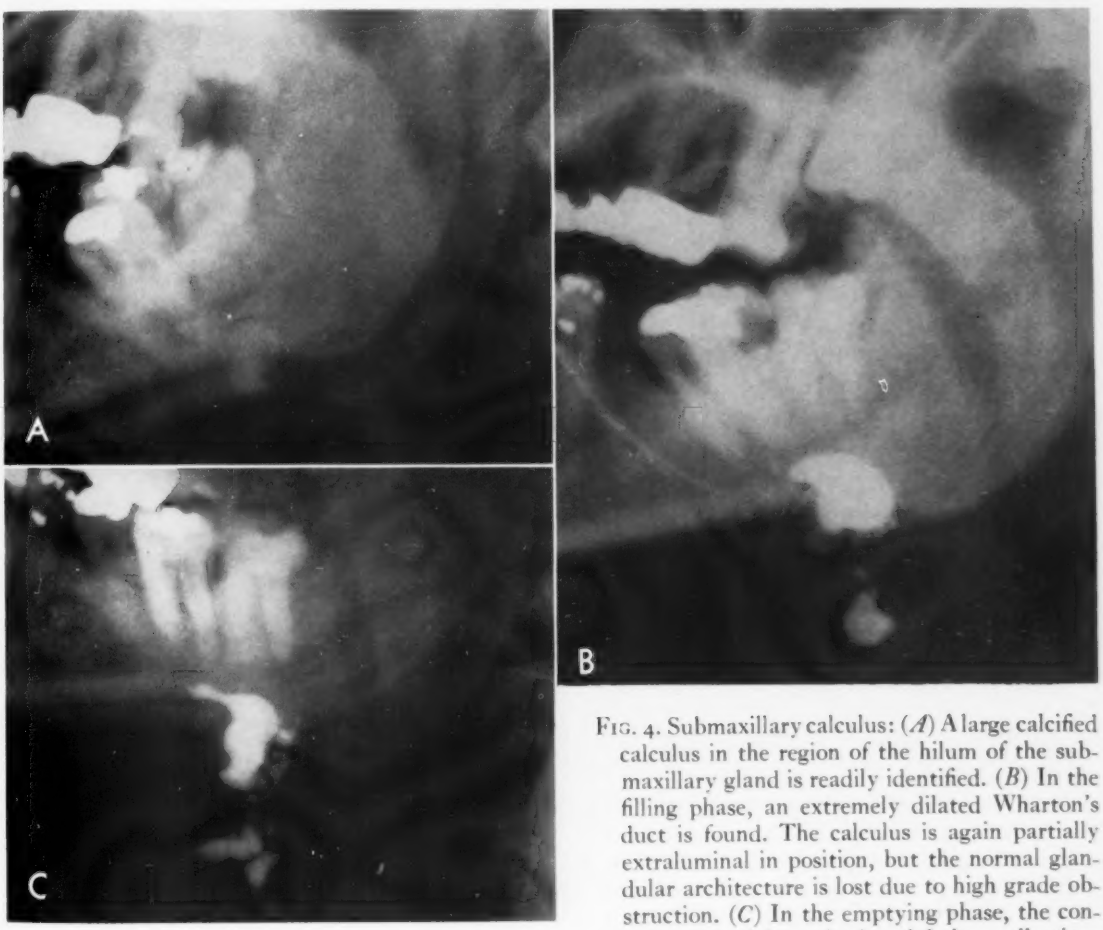

Fig. 4. Submaxillary calculus: (*A*) A large calcified calculus in the region of the hilum of the submaxillary gland is readily identified. (*B*) In the filling phase, an extremely dilated Wharton's duct is found. The calculus is again partially extraluminal in position, but the normal glandular architecture is lost due to high grade obstruction. (*C*) In the emptying phase, the contrast material pools in globular collections suggestive of abscesses. In removing the calculus, the gland was excised since it was nonfunctioning and formed a focus of infection.

ducts appear normal (Fig. 3*B*). In chronic cases loss of the arborial pattern of the normal gland is seen due to atrophy of the parenchyma. The pattern of nonobstructive sialodochiectasis is not seen when secondary infection occurs. The dilatation of the main duct, the loss of terminal arborization, and the irregular distribution of small collections of contrast material resemble abscesses (Fig. 4*B*) rather than the "mulberry" appearance of sialectasis and serve to differentiate this condition from recurrent nonobstructive sialadenitis. Occasionally, calculi may erode the wall of the main duct; if extraglandular, they form pseudodiverticula, but if intraglandular, atypical abscesses and granulomas may result. When total obstruction has occurred, probing of duct may be insufficient to rule out stricture and sialography in this situation is of value in establishing the diagnosis.

Strictures at the duct orifice may lead to considerable dilatation and tortuosity of the main salivary channel. Often dilatation of the papillary orifice, while inserting the catheter for sialography, cures the patient. In patients with masseter muscle hypertrophy symmetric medial defects are found in parotid sialograms. Multiple strictures following a severe case of pneumococcal parotitis lead to a "sausage-string" appearance[29] of Stensen's duct.

Secretory Phase. Although post-stimulation films are of limited clinical value in this disease, they demonstrate some changes which may explain the symptomatology and the process of dilatation of the main duct. The ball-valve mechanism illustrated in Figure 2*B* demonstrates the basis of pain and swelling which may be precipitated by eating. The continual pressure exerted by salivary flow may force the stone from the duct, but in the process diltation of the ducts results from the accumulated secretions. As evidenced by the emptying films in Figures 3*C* and 4*C*, the functioning capacity of the gland can be determined.

Pathologic Correlation. The histologic sections in obstructive sialodochiectasis are in sharp contrast to those of nonobstructive disease. The ducts which are dilated are the main duct and the larger interlobar and interlobular septal channels (Fig. 5*A*). In cases where obstruction has been of short duration, the acinar tissue and peripheral ducts may be normal. In advanced cases, as complete block supervenes, scarring and fatty atrophy of the gland predominate and the intralobular ducts are obliterated, accounting for the loss in arborial sialographic pattern (Fig. 5*B*). Secondary infection following obstruction is evident by the polymorphonuclear cells in the lumen of

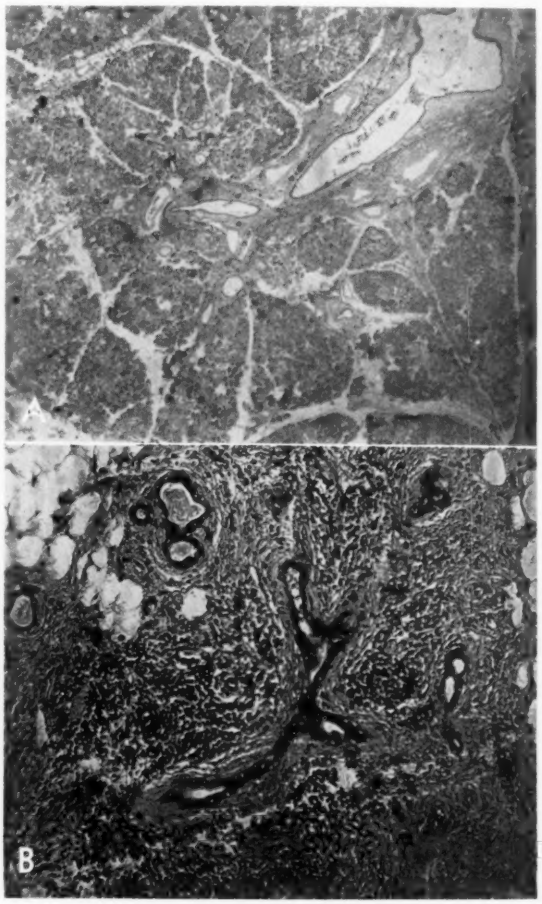

Fig. 5. Pathologic correlation of obstructive salivary gland disease with sialograms: (*A*) On histologic section the larger *interlobular* and *interlobar* ducts (upper right), which run in the septa of the gland, are dilated. The *intralobular* ducts are not enlarged. (Magnified 24×). (*B*) The obliteration of the *intralobular* ducts occurs due to scarring and fatty atrophy following prolonged obstruction to salivary flow and secondary infection. (Magnified 100×.)

the finer ducts. In virulent infections, abscesses and fistulas may occur.

2. Chronic Nonobstructive Sialodochiectasis (Referred to in the literature as sialectasis).* A review of the literature is necessary to provide the background for our proposed concept of this heterogeneous but clinically related group of cases. In 1892, Mukulicz[17] described a patient with a benign, asymptomatic enlargement of the lacrimal and salivary glands. Microscopic examination of excised portions of the glands disclosed atrophy of the glandular parenchyma and diffuse replacement by lymphoid tissue. In the years that followed Mikulicz's disease became a confused subject because many cases of enlarged salivary and lacrimal glands were diagnosed as Mikulicz's disease. It soon became apparent that some patients ran a course which was benign and self-limited, whereas others were rapidly fatal. Since pathologic reports differed widely, Thursfield[39] in 1914 classified the syndrome on an etiologic basis. He divided all cases showing enlargement of the salivary and lacrimal glands into eight groups: a congenital, familial, and hereditary condition; Mikulicz's disease proper; Mikulicz's disease with involvement of the lymphoid tissues; leukemia; tuberculosis; syphilis; gout; and sialodochitis fibrinosa. In 1927, Schaffer and Jacobsen[33] modified this grouping into two large categories: Mikulicz's disease proper and Mikulicz's syndrome, which is commonly used to this day. This classification is dependent on microscopic sections of biopsy or necropsy material. Those cases which do not fit well-recognized pathologic entities are called Mikulicz's disease of unknown etiology. Mikulicz's syndrome is caused by lymphoblastoma, sarcoidosis, tuberculosis and other diseases.

With the advent of sialography a group of cases were separated from the Mikulicz group and the term "sialectasis" was applied because the roentgenographic finding of dilated terminal ducts was similar to the appearance of bronchiectasis on brochograms. The first recorded cases in the literature were those of Keith[12] and Pyrah and Allison,[28] both of which were in children. Excellent reviews of recurrent sialadenitis in children were presented by Londe and Pelz[15] (1933) and Pearson[27] (1935). From 1931 to 1940, Payne[24,25,26] recorded his extensive experiences with sialography in patients with recurrent pyogenic parotitis, the majority of whom were premenopausal and menopasual women. His paper[25] in 1937 included a series of 208 cases; this is one of the most carefully documented and studied groups of patients with infectious parotitis of different etiology.

Two cases of parotitis, reported by Payne, were thought to be examples of "Sjögren's syndrome" by Ollerenshaw and Rose.[21] Rose[30] in a review of 192 cases of recurrent salivary gland swellings, stated that the spectrum ranged from "recurrent swelling of one parotid gland in an otherwise normal patient through cases of bilateral gland involvement—to fully developed Sjögren's syndrome." The salient features were the same in patients with Sjögren's syndrome and recurrent parotitis and the roentgenologic pattern was that of sialectasis. Parrot[22] attempted to clarify the condition of the parotid gland in Sjögren's syndrome by classifying the stage of the illness according to the intensity of the destructive process as noted on sialograms. Although the published films in this article are excellent, clinical details and tissue correlation are lacking. The clinical similarity of Parrot's patients to those described by Payne[24] is matched by the parallels in the classification of the sialographic abnormalities identified by these authors.

Morgan and Castleman[18] provided the connecting link between Mikulicz's disease and Sjögren's syndrome. After a careful review of the available pathologic material they felt that the microscopic sections in both conditions were similar and therefore

* The term sialectasis, used to describe the abnormal dilatation of the peripheral ducts of the salivary gland, is not correct etymologically, translating as: "a stretching out or dilatation of saliva." Swinburne has suggested sialangiectasis. Although nonobstructive sialodochiectasis is preferred since it is a more accurate descriptive term, we shall continue to use sialectasis because it is in common usage and is less cumbersome.

concluded that Mikulicz's disease was a less highly developed variant of a larger symptom complex, the sicca or Sjögren's syndrome. Further evidence to relate these clinical groups is found in the correlated sialographic studies to be presented in this paper. It is best to briefly describe the clinical types that produce sialectasis and present some case illustrations before discussing the common sialographic-histopathologic denominator.

a. Recurrent Sialadenitis in Children. The enlargement of the parotid gland or glands in this condition has a tendency to recur and to be painful. It may last hours to days or weeks, the gland remaining moderately enlarged between exacerbations. There is as a rule no febrile reaction and the general health of the patient is unaffected. Pressure on the gland may cause the appearance of frank pus, a cylindrical mass of fibrin and pus or gelatinous saliva. The gland is tense to palpation and tender during an exacerbation and, between attacks, is firm and nodular. In the analysis of the 18 cases collected by Londe and Pelz[15] and the 13 cases added by Pearson,[27] the ages ranged from one month to sixteen years and were equally divided by sexes.

b. Recurrent Pyogenic Parotitis in Adults. Recurrent, tense swellings of the parotid glands are the predominant symptoms in this group of patients. The onset is often insidious and preceded by a febrile illness but may be precipitated suddenly while eating. Although the enlargement is usually bilateral, one side may be involved more than the other (Fig. 6) and in long-standing disease the submaxillary glands may also be involved (Fig. 7). The swelling

Fig. 6. Recurrent pyogenic parotitis in an adult: Bilateral sialectasis more advanced on the left side: (*A*) The right parotid gland shows a diffuse punctate dilatation of the peripheral ducts and a striking decrease in the number of the intraglandular septal ducts. (*B*) The left parotid gland shows irregular cystic or globular cavities replacing the acinar pattern.

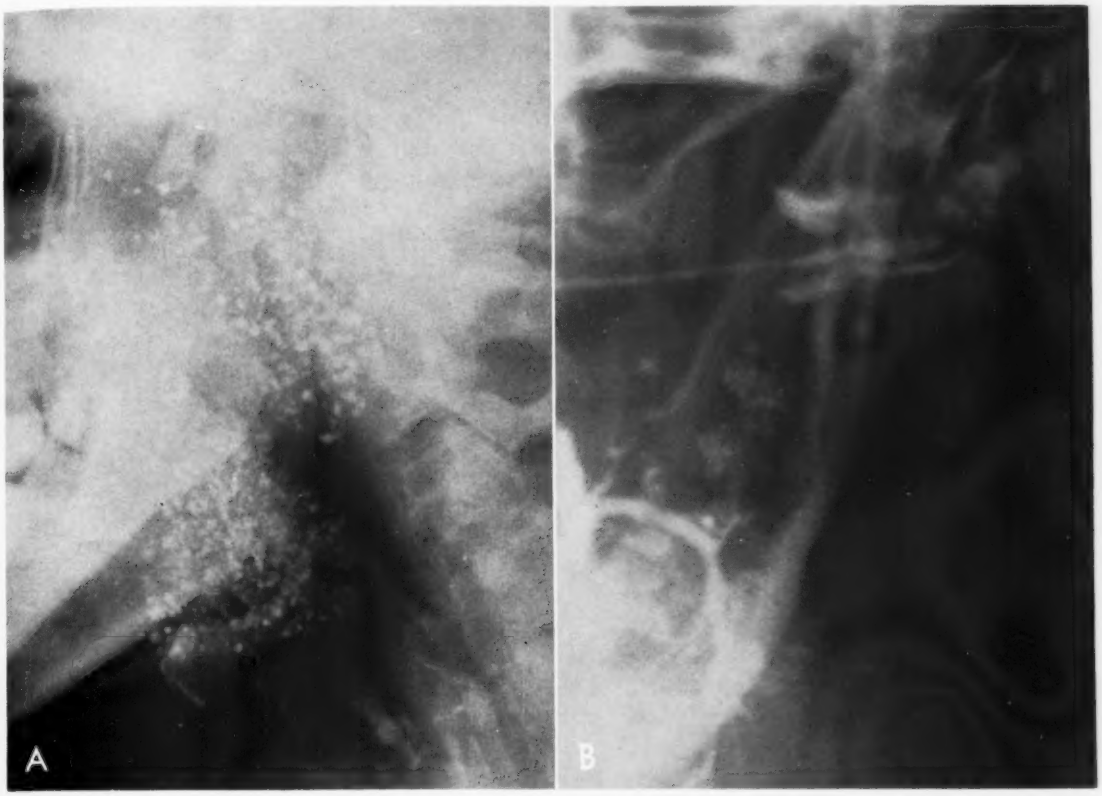

Fig. 7. Sjögren's syndrome: (*A*) Involvement of both the submaxillary and the parotid gland by nonobstructive sialodochiectasis. This is the first case of submaxillary sialectasis published to the knowledge of the authors. (*B*) The parotid gland architecture is bizarre and compatible with the destructive stage of this disease. The contrast material appears to have permeated the septa of the gland. Also, note the associated submaxillary sialectasis.

of the gland usually lasts from three to ten days, although longer periods up to two to three months have been recorded. This inflammatory process occurs mainly in women during the fourth and fifth decades of life and only rarely in men. At first the swelling subsides completely between attacks, leaving only a slight thickening. Later it persists and the entire gland may become palpable; the surface becomes smoothly nodular and the gland is rubbery in consistency. Upon massaging the gland, the saliva is a cloudy and scant mucopurulent secretion which may be inspissated. When smeared and examined microscopically, the saliva contains desquamated cells and bacteria, giving a "snowstorm" effect. On culture, *Streptococcus viridans* is commonly found but such organisms as typhoid bacilli and diphtheroids have been recorded.

c. Sjögren's Syndrome. The main features of the "sicca syndrome" as described by Sjögren[36] are decreased or absent lacrimation associated with a dry, filamentary keratitis and conjunctivitis (keratoconjunctivitis sicca), dryness of the mucous membranes of the nose, mouth and throat (rhinopharyngo-laryngitis sicca), enlargement or atrophy of the parotid gland (sialoadenopathia atrophicans) and chronic rheumatoid polyarthritis. It is a chronic, progressive disease, although remissions have been reported, and usually occurs in women over 40 years of age. Recently many other signs and symptoms have been added to this syndrome including scleroderma, dry, atrophic vaginitis, achylia, pernicious ane-

mia, Raynaud's phenomena, purpura, alopecia, acrodermatitis atrophicans and others. Sjögren discussed the addition of other symptoms to the syndrome and stressed the "formes frustes" cases at the other end of the clinical spectrum; *i.e.*, those patients lacking one or two of the main symptoms may be incomplete examples of the "sicca syndrome" and later develop the full picture. He stated that xerostomia was associated with keratoconjunctivitis in 50 per cent of the patients and arthritis in 64 per cent. No causal connection between the articular and other symptoms was noted but Sjögren felt that all symptoms were an expression of a generalized disease with a common etiology. The causes suggested have been endocrine, allergic, avitaminosis, chronic infection and neurotrophic.

d. Mikulicz's Disease. Clinically, Mikulicz's disease is characterized by chronic painless enlargement of the salivary and lacrimal glands. Follow-up studies for decades in some series of cases have attested to the benign character of the disease process. The disease occurs predominantly in females, the majority of whom are in the fourth to sixth decades of life. In contrast to Mikulicz's contention that the disease is always bilateral and involves the lacrimal gland is the recent report by Morgan and Castleman[18] that more than one-half of their cases had a unilateral distribution usually confined to the salivary glands. Although many authors[5,35] examined cases of Mikulicz's disease, all reported normal duct patterns except for some minor changes. This discrepancy between the marked abnormality noted in histologic sections and the normal sialograms is often due to the absence of biopsy specimens to verify clinical impressions.

SIALOGRAMS OF NONOBSTRUCTIVE SIALODOCHIECTASIS

No previous attempt apparently has been made to explain why this diversified group of cases yields a similar and characteristic roentgenographic pattern of "sialectasis." The reason for this is that most workers did not biopsy these cases in view of the inflammatory nature of the disease. We believe that biopsy material is necessary to give us some insight into the nature of the underlying pathologic process. The correlation of microscopic sections with sialograms has helped to explain some of the variations and similarities noted.

Scout Films. The preliminary films generally show soft tissue swelling. In advanced cases scattered fine nodular calcific densities are seen in the gland. The most striking case of diffuse calcinosis of the parotid glands was reported by Payne in a woman, aged thirty, with associated Raynaud's phenomena and scleroderma.

Filling Phase. The following classification is proposed and incorporates the reports in the literature as well as our own observations:

1. Punctate: The earliest findings are characterized by a diffuse punctate dilatation of the peripheral ducts which may be less than 1 mm. in size. The main duct is of normal caliber but a striking decrease in the number of the intraglandular ducts is immediately apparent. Careful examination shows that the lumina of the second to fourth order ducts are narrowed to fine linear channels. The entire gland parenchyma is involved, including the accessory lobe if it is present (Fig. 6*A*).

2. Globular: In moderately advanced disease, the globules of contrast material increase to 1–2 mm. in diameter but remain uniform in size and distribution. The main duct still remains normal in caliber but the intraglandular duct divisions are no longer seen. The appearance is that of a branchless fruit laden tree and has been referred to in the literature as the "mulberry" pattern (Fig. 7*A* and Fig. 8*A*).

3. Cavitary: In advanced stages, there is a coalescence of these globules which now become irregular in size and distribution and decreased in number. Filling defects suggestive of cystic dilatation are noted (Fig. 6*B*).

4. Destructive: In the end stages, there is a bizarre pattern which suggests neoplastic invasion and destruction of the

gland parenchyma. It should be stressed that during the destructive stage of chronic inflammation, the picture may simulate an invasive neoplastic process clinically[37] and roentgenographically. The differential point at this stage lies in the fact that other glands, whether swollen or not, will show the manifestations of sialectasis (Fig. 7*B*).

Emptying Phase. The degree of emptying following stimulation adds to the knowledge of the altered pathophysiology in the diseased gland. The retention of the contrast material in the terminal ducts is due to the inability of the secretory pressure of the acini to overcome the resistance offered by the narrowed interstitial or septal ducts. The retained fluid results in dilatation of the intralobular duct. The larger the size of the retained globule, the greater the obstruction and the slower the contrast material empties (Fig. 8). Serial films taken at intervals of five minutes, one-half hour, one hour and twenty-four hours permit evaluation of the degree of secretory function in cases where scant flow exists (Fig. 9). The failure of Stensen's duct to empty as shown in the five minute stimulation film is in keeping with the degree of xerostomia seen clinically. The bizarre pattern of the end stage remains unchanged for days to weeks since no acinar tissue remains, and the contrast material has permeated the gland septa.

Pathologic Correlation. The common denominator in sections of tissue from patients with chronic nonobstructive sialodochiectasis is that of an inflammatory response regardless of whether the irritant is an infectious agent, an allergic or hyperimmune phenomenon or a chemical injected into the ducts. The tissue response is the same with infiltrations of leukocytes and lymphocytes into the interstitial septa of the gland. The inflammatory changes have three features: exudation, proliferation and retrogression. The changes differ in intensity depending upon the etiologic agent and duration of the disease.

The earliest finding in chronic sialadenitis is that of periductal lymphocytic infiltration around the interlobar and particularly

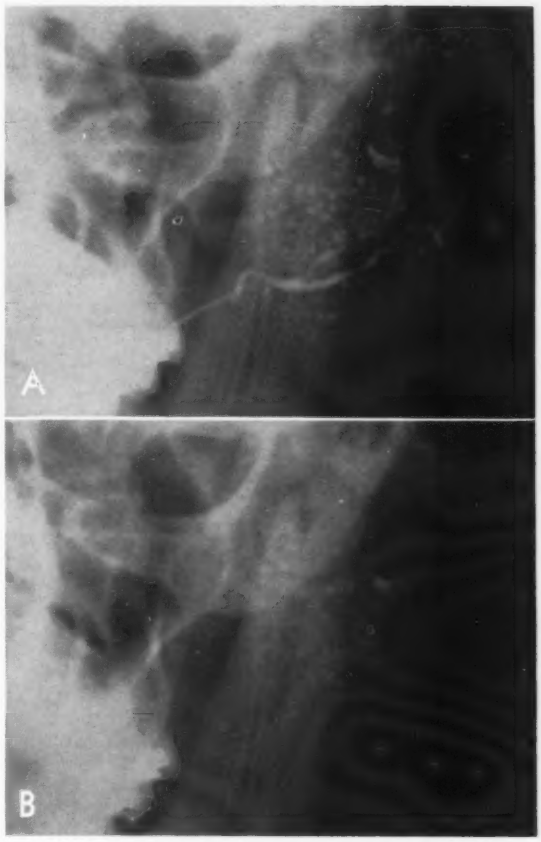

FIG. 8. Mikulicz's disease: (*A*) In the filling phase the pattern of sialectasis in the globular stage is seen. (*B*) Following stimulation, the amount of retention of small globular collections in the intralobular ducts reflects the degree of narrowing of the interlobular septal ducts and the amount of residual functioning acinar tissue.

the interlobular ducts in the septa of the salivary gland. Following this stage of exudation, proliferation of fibroblasts occurs and collagen fibers appear. In recurrent parotitis in children and adults, the scarring increases following exacerbations and results in stenosis of the interlobular ducts. Although we have only one biopsy in this group, Tietze[40] and Thaysen,[38] who obtained parotid glands from a four month old infant and from a three year old child respectively, have reported the same microscopic features. Both authors described a marked increase of interlobular connective tissue, with fibrous tissue replacement of the lobules and marked inflammatory cellular infiltration.

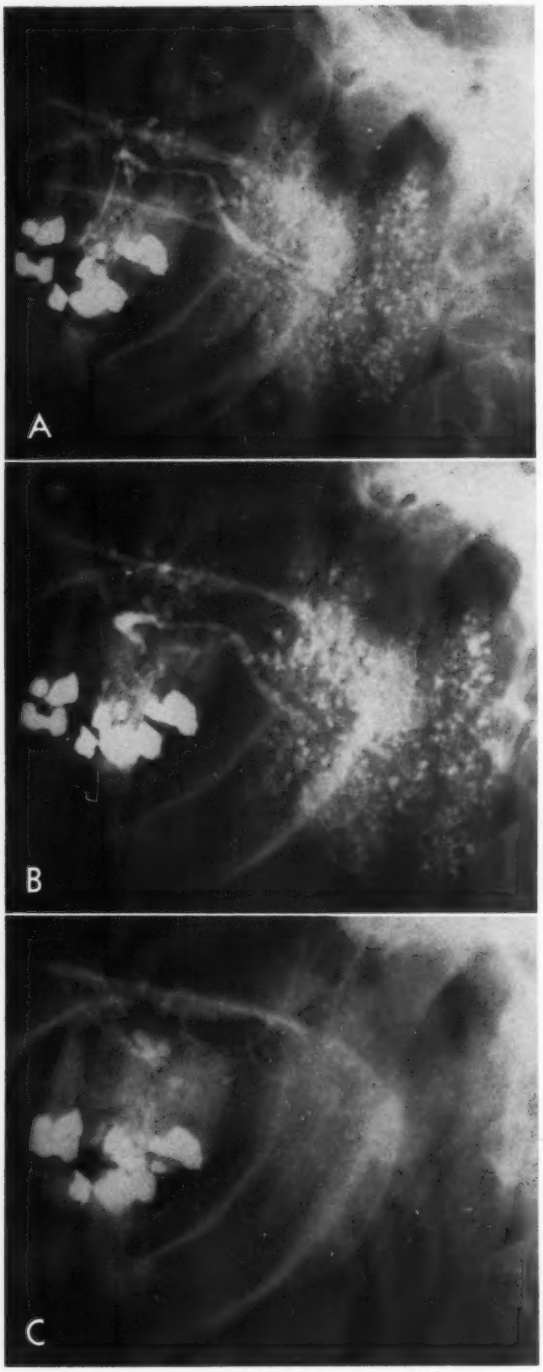

Fig. 9. Sjögren's syndrome: (*A*) The typical "mulberry" pattern of the globular stage of sialectasis is seen. Note the involved accessory lobe. This is typical of sialectasis in which the entire gland is involved. (*B*) At five minutes poststimulation, the lack of salivary flow is verified by the unaltered appearance of the sialogram. (*C*) One hour later, the contrast material has been almost completely evacuated.

In Mikulicz's disease and Sjögren's syndrome, there is an element of myoepithelial cell hyperplasia which also tends to narrow the lumen of these interlobular ducts. Functioning acinar tissue continues to secrete against a narrowed duct system, resulting in retention of some saliva in the intralobular ducts which then dilate. It is at this stage that the sialographic findings of terminal duct dilatation and lack of intraglandular branching correlate well with the sparcity of interlobular and interlobar ducts located in the septa of the gland and the wide lumen of *intralobular ducts* in the microscopic sections (Fig. 10*A*).

With exacerbations and continued progression of this inflammatory process, lymphoid infiltration replaces the parenchyma. Increasing fibrosis results in loss of acini and myoepithelial cells line and tend to obliterate the lumina of the intralobular ducts. Some areas are less involved and these ducts continue to dilate and form cysts resulting in a cavitary appearance. In the advanced cases of Mikulicz's disease and Sjögren's syndrome, reported by Morgan and Castleman among others, are the myoepithelial islands or buds scattered in areas of lymphoid infiltration and fibrosis and total absence of any recognizable ducts. It is interesting that Payne found a similar epithelial proliferation of the duct lining in the one biopsy specimen from a case of recurrent pyogenic parotitis. The present authors do not feel that these changes are specific for Mikulicz's disease and have encountered these findings in lymphoblastoma. In the end stages, total absence of the glandular architecture and parenchymal atrophy result from the diffuse lymphocytic infiltration (Fig. 10*B*) and account for the bizarre and destructive pattern seen in the sialograms. Scattered areas of calcification are occasionally seen.

II. NEOPLASTIC DISEASE

Tumors external to the salivary glands are more often the cause of regional swelling about the angle and below the ramus of the mandible than are intrinsic salivary gland neoplasms. Metastatic adenopathy

and lymphomas are frequently seen as painless masses in the cervicofacial region. Tuberculous, syphylitic and other infectious types of lymphadenitis are encountered less frequently and may be associated with primary oral lesion. Tumors derived from the neighboring tissues, any of which may be a potential source of tumefaction, are problems in differential diagnosis. These include neurofibroma, lipoma, lymphangioma, chemodectoma, adamantinoma, branchiogenic cyst and aneurysm.

A. Extrinsic Tumors: The first report of ultilization of sialography to determine whether the salivary glands were involved by neoplasm was made by Kimm, Spies and Wolfe.[13] The main criteria for ruling out glandular involvement rested upon demarcation of the margin of the normal gland from that of the tumor. In many of the cases these authors did not distinguish external tumors from encapsulated intrinsic neoplasms in which the glandular architecture was preserved. This shortcoming in sialography was emphasized by Blady and Hocker,[4] who stated that the roentgen findings of benign mixed salivary gland tumors were simulated by benign growths, cysts, tuberculous adenitis and lymph nodes with metastases.

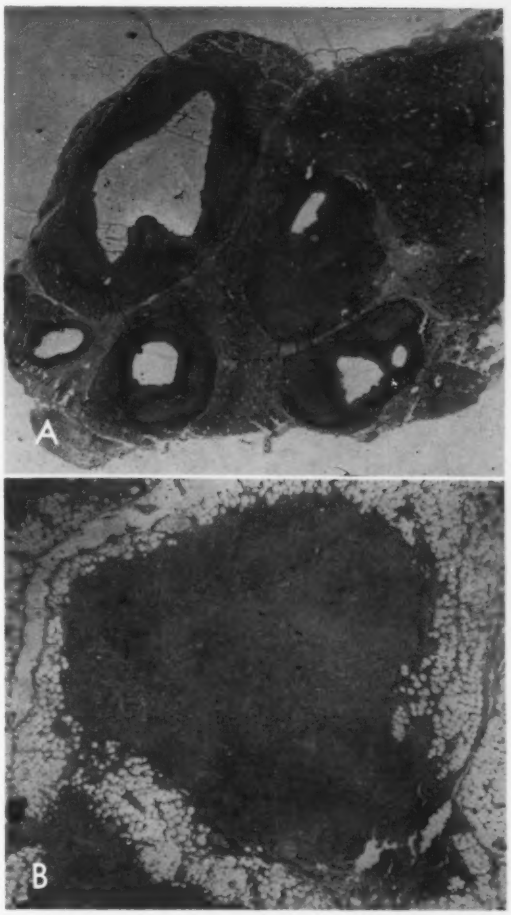

Fig. 10. Pathologic correlation of nonobstructive salivary gland disease with sialograms: (*A*) Histologic section showing dilatation of *intralobular* ducts and sparcity of *interlobular* septal ducts in contrast to the findings of obstructive inflammatory disease. This parallels the sialographic findings of dilated terminal ducts and lack of intraglandular duct branching. (Magnified 25×.) (*B*) In the destructive stages, the entire ductal system is destroyed by scarring, lymphocytic infiltration and myoepithelial hyperplasia of duct lining.

SIALOGRAPHY OF EXTRINSIC NEOPLASMS

Scout Films. Preliminary roentgenograms occasionally make the diagnosis obvious, precluding the use of sialography. Mandibular tumors and the characteristic "mulberry" calcification in a chain of tuberculous lymph nodes are readily identified.

Filling Phase. A normal sialogram, in both size and configuration, may indicate that the cervical mass is external to the gland. More often the problem is not solved so easily since juxtaposition of the tumor and gland distorts the duct system. The abnormal sialographic pattern produced by neighboring tumors which do not actually involve the gland is dependent upon their extracapsular location (Fig. 11*A*). The general architecture of the gland is preserved and there is only slight deviation of the intraglandular ducts with an absence of localized narrowing, sharp kinking or bending. The filling defects are marginal and the bordering acinar pattern remains feathery (Fig. 12*A*). There is rarely a true "lack or partial visualization of the smaller ducts in the affected region" but rather crowding together of acini and terminal ducts in the compressed portion.

Emptying Phase. Secretory sialography is valuable in identifying extrinsic tumors since complete emptying of the ducts and acini occurs immediately following stimula-

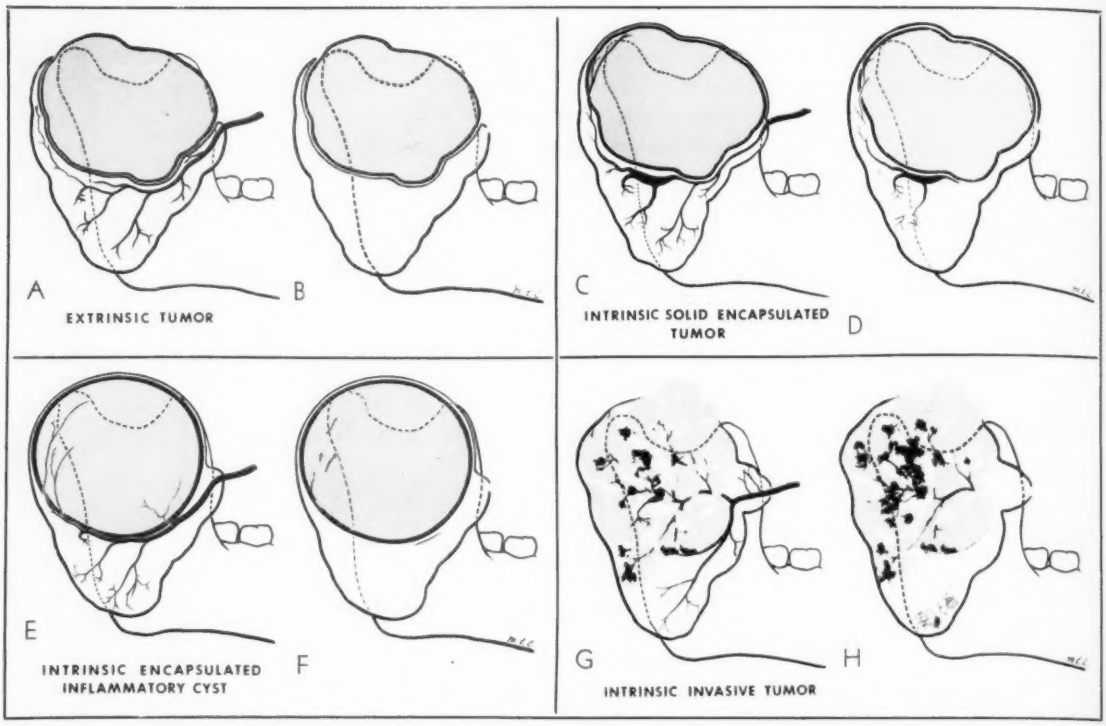

Fig. 11. Tumors of the salivary glands: (*A*) Extrinsic tumor, filling phase. The glandular architecture is preserved but displaced. The acini are compressed and the ducts are intact. (*B*) Extrinsic tumor, emptying phase. The duct system empties normally since the tumor is extracapsular and the glandular parenchyma functions normally. (*C*) Intrinsic solid encapsulated tumor, filling phase. The glandular architecture remains intact but the intracapsular position of the nodular tumor allows it to impinge on the duct system, causing localized narrowing. The surrounding acini may be lacking due to atrophy. (*D*) Intrinsic solid encapsulated tumor, emptying phase. Trapping of contrast material in the duct system distal to the site of narrowing is characteristic of intrinsic tumors. (*E*) Intrinsic encapsulated inflammatory cyst, filling phase. A large filling duct, smooth in its general contour stretched the adjacent ducts. No localized narrowing is seen since the pressure of the cyst is applied evenly over the length of the duct. (*F*) Intrinsic encapsulated inflammatory cyst, emptying phase. Since there is no area of localized obstruction of the duct system as in solid, nodular tumors, the contrast material is almost completely evacuated. (*G*) Intrinsic invasive tumor, filling phase. The normal ductal and acinar architecture is completely replaced by a bizarre puddling and pooling of contrast material. (*H*) Intrinsic invasive tumor, emptying phase. The pattern remains essentially unchanged except for further diffusion of the contrast medium since the glandular parenchyma, replaced by invasive neoplasm, has lost its secretory function.

tion (Fig. 11*B* and 12*B*). This is to be expected since the parenchyma is displaced but intact and functions normally. This is one of the most valuable points in distinguishing extrinsic from intrinsic neoplasms for in the latter some retention of contrast material usually is present in postevacuation roentgenograms.

Pathologic Correlation. The various pathologic entities encountered external to the gland are beyond the scope of this paper.

Tumors of the parotid and submaxillary glands generally are characterized by an insidious onset. In many instances the gradual and painless growth of the neoplasm lulls the patient and the physician into a false sense of security. There are no early clinical findings to help identify the malignant character of salivary gland tumors. A history of change in the growth pattern is the most frequent cause of concern to the patient; a sudden increase in size of the swelling and/or the onset of pain are the reasons for seeking medical

advice and attention. Facial nerve palsy, metastatic cervical lymph adenopathy and, more rarely, distant metastases are signs of advanced disease. The neoplastic masses are firm and nodular on palpation. The consistency of neoplasm is not an indication of malignancy since the fibrous, cartilaginous, and even ossified components of mixed salivary gland tumors often have a stony quality. If a cystic lesion is located superficially, transillumination may establish the diagnosis. The size of a neoplasm is difficult to estimate since much of the tumor may lie in the deep portion of the gland in a retromandibular position. Occasionally, early evidence of facial paresis is detected, although the patient may not be aware of it.

B. Intrinsic Tumors: Early reports of cancer of the salivary glands often were based on clinical and roentgenographic findings and many were not substantiated by histologic sections. Jacobovici, Popolitza and Albu[11] (1926) reported two cases showing "deformity of ducts" but gave no pathologic findings. Barsky and Silberman[2] in 1932 stated that absence of duct markings in the region of tumor indicated a "malignant character of the tumor" but failed to report the microscopic findings of half of the 6 cases documented. Csillag and Czunft[7] in 1934 stated "cancer of the parotid gland can be recognized by the destruction of the finer ramifications of the excretory ducts and by filling defects due to the destruction of the glandular substance." One of the most accurate and complete analyses of salivary gland tumors was by Blady and Hocker[4] in 1937. They reported clinical, roentgenographic and pathologic observations of 76 tumors of the salivary

Fig. 12. Extrinsic tumor: (*A*) In the filling phase, there is a medial filling defect in the right parotid gland. The accessory lobe is displaced laterally. (*B*) In the postevacuation film, the gland has completely emptied, indicating the parotid gland is not actually involved.

gland, 24 of which were malignant, and established the diagnostic criteria generally accepted.

SIALOGRAMS OF INTRINSIC NEOPLASMS

It is apparent that it is impossible to know the histologic type of the neoplastic process by sialography. Generally speaking, benign neoplasms are circumscribed or encapsulated and malignant tumors are infiltrative. However, the converse of this statement is not always true. For example, encapsulated masses may be benign in their gross appearance, but microscopic evidence of malignant change may be found. Encapsulation and invasion are distinguishable on sialograms and form the basis for reporting tumors of the salivary glands (Fig. 11, *C–H*).

Scout Films. Screening films as a rule are not very helpful. Rarely, an amorphous collection of calcification in a soft tissue mass may suggest calcifying cartilaginous tissue in a mixed salivary gland neoplasm. When there is destruction of the mandible, it usually is due to neoplastic disease arising in this bone.

Filling Phase. The most consistent roentgen finding of an encapsulated or circumscribed intrinsic lesion is a filling defect outlined by a displaced duct system. The general architectural pattern of the duct system is preserved; each duct is seen in its entirety, although its shape and configuration will vary with its degree of displacement. The position and size of the tumor determine the sialographic findings. Centrally situated masses result in wide separation of the larger adjacent subsidiary intraglandular ducts (Fig. 13*A*). If the tumor is located peripherally, the displacement of the terminal arborization may simulate an extrinsic mass (Fig. 14*A*). The main duct is more sharply angulated by the pressure of masses in the anterior portion of the gland.

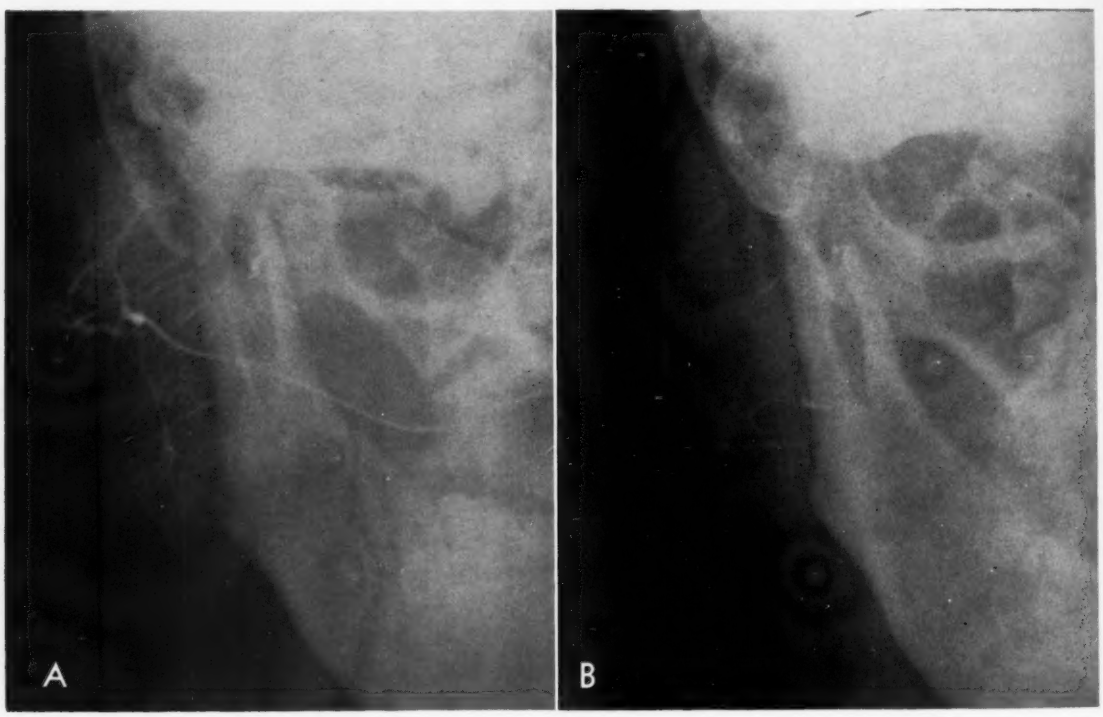

Fig. 13. Intrinsic solid encapsulated tumor: (*A*) Following retrograde injection of radiopaque material, a central filling defect in the superficial lobe of the parotid gland displaces the adjacent intraglandular ducts. The ducts, however, are intact. (*B*) In the postevacuation film, retention in the peripheral ducts identifies the tumor to be intrinsic and encapsulated.

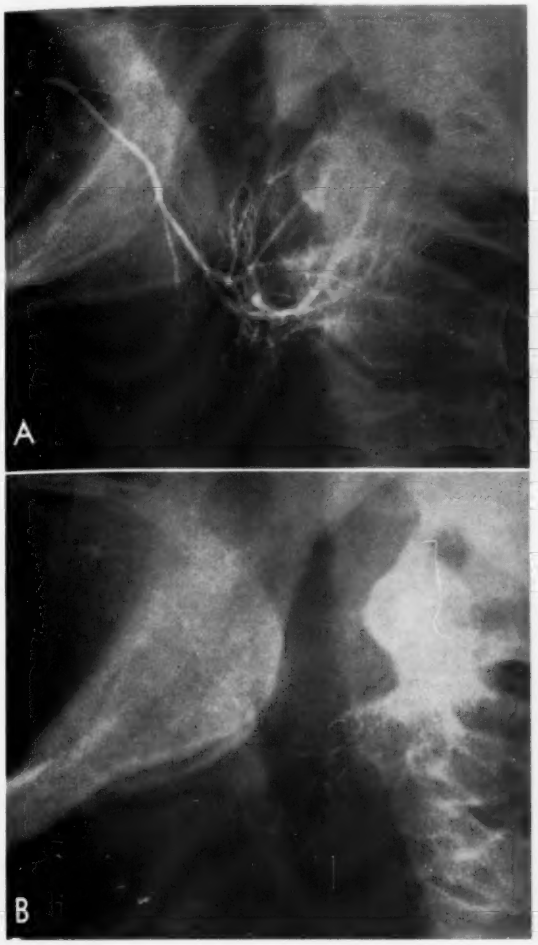

Fig. 14. Intrinsic solid circumscribed tumor: (*A*) In the filling phase, there is a filling defect in the superior pole of the right parotid gland with displacement of the gland inferiorly. There is slight dilatation of the interlobar ducts distal to the site of narrowing. (*B*) In the emptying phase, there is a considerable amount of contrast material trapped in the distal duct system indicating low grade partial obstruction to salivary flow.

Circumscribed masses may be solid neoplasms or fluid-filled cysts; both present problems in differential diagnosis clinically and on sialographic examination. Cystic lesions are more round and symmetric but, occasionally, are loculated. Cysts, mainly inflammatory in nature, expand evenly by the steady accumulation of fluid according to Pascal's principle.* The ducts

* Pascal's principle: When pressure is added to a collection of liquid at any place while at rest, the pressure everywhere throughout the liquid is increased by an amount exactly equal to the pressure added.

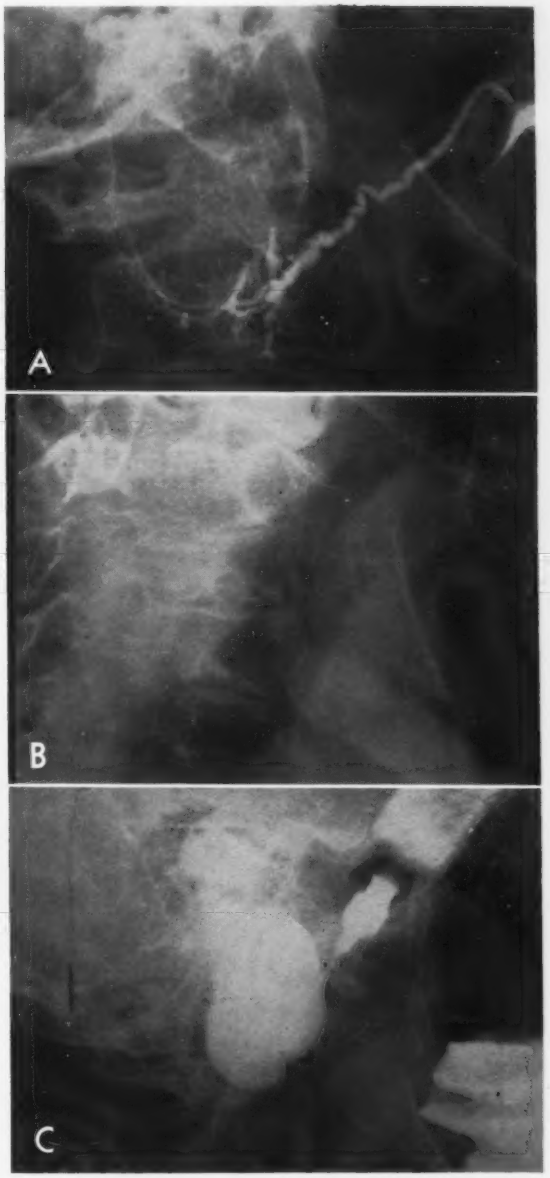

Fig. 15. Intrinsic encapsulated inflammatory cyst: (*A*) The filling phase shows tortuosity and dilatation of Stensen's duct compatible with simple duct obstruction. A space occupying mass in the posteromedial portion of the gland stretches the secondary and tertiary ducts. The duct system is intact. (*B*) There is complete emptying on post-evacuation films except for some faint shadows which cannot be reproduced. This disparity between the large size of the mass and the very small amount of retained pantopaque is suggestive of a cystic lesion. (*C*) Aspiration of 17 cc. of fluid followed by the injection of a comparable amount of 30 per cent urokon outlines the smooth-walled cavity of the cyst.

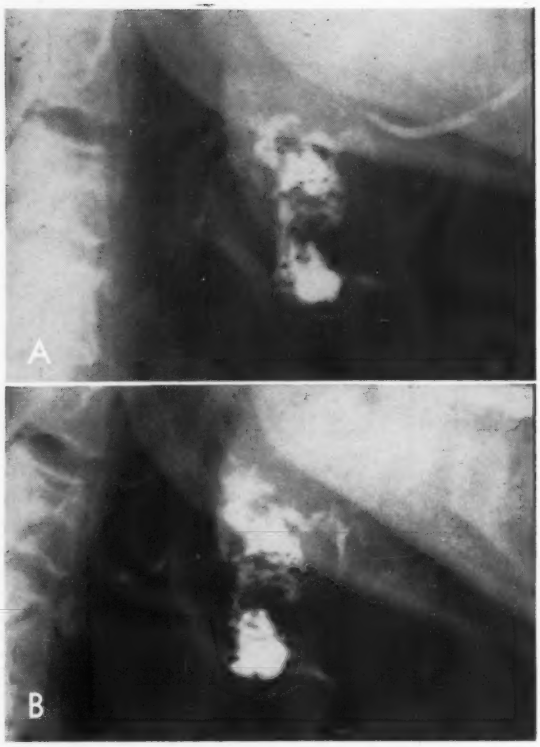

Fig. 16. Intrinsic invasive tumor: (*A*) In the filling phase, total destruction of the normal duct architecture is seen with puddling and pooling of the contrast material. Evidence of retrograde lymphatic flow is present. (*B*) Following stimulation, there is no change in the pattern, indicating loss of salivary flow due to tumor invasion and destruction of the acini.

surrounding the cysts are stretched and thinned in a diffuse manner by the fluid (Fig. 15*A*). A benign solid neoplasm tends to be nodular in outline. These encapsulated tumors increase in size apparently by proliferation of cells, particularly at the periphery of the mass. A nodular excrescence may cause focal narrowing or partial obstruction of a secondary or tertiary duct by the pressure of its growth.

Malignant neoplasms are generally infiltrative in type. The architecture of the gland is disrupted and the degree of the sialographic abnormality is dependent upon the extent of involvement. The duct system is displaced and distorted by the expanding neoplasm. The acinar pattern is replaced by a bizarre puddling and pooling of the radiopaque medium since the terminal ducts are destroyed by neoplastic invasion and the injected contrast material escapes into the adjacent tissues (Fig. 16*A*). Blady and Hocker[4] noted that these changes were present only in 62 per cent of their cases of primary carcinoma of the salivary gland. The reason for the failure to demonstrate this change may be due to the fact that with carcinomatous degeneration occurring in encapsulated lesions no evidence of infiltration is present.

Emptying Phase. Following reflex stimulation of salivary glands with internal neoplasms, retention of contrast material in distinguishing patterns has been noted. The normal gland parenchyma is compressed between the slowly growing encapsulated solid neoplasm and the fibrous capsule of the gland. This may result in two diagnostic patterns each of which is characterized by some evidence of segmental intraglandular duct retention. The differences are due to anatomic location and size of the growth. (1) Minimal retention of radiopaque material in the tertiary and quaternary branches (inter- and intralobular ducts) and acini with evidence of localized narrowing is caused by peripherally located neoplasms. Loss of secretory activity occurs and retention of material is found in the peripheral ducts on sialograms (Fig. 13*B*). (2) Retention in distally dilated second order branches (interlobar) of ducts is due to localized narrowing in centrally situated masses (Fig. 14*B*). The pressure of the injection of the contrast material is sufficient to overcome the compromised lumen of the duct, but the pressure of salivary secretion is insufficient to evacuate the contrast material.

Cystic lesions when uncomplicated by previous surgical procedure result in a small degree of ductal retention following stimulation in comparison to the size of the filling defect (Fig. 15*B*). This is to be expected since the ducts adjacent to collections of fluid are uniformly reduced in caliber and the surrounding parenchyma is not atrophic and retains its secretory function. Large circumscribed tumors may be a

mixture of cystic and cellular areas making the differential diagnosis from a solitary cyst impossible by sialography alone. If the clinical findings and secretory sialograms suggest cystic salivary gland disease, an attempted aspiration of the intrinsic encapsulated lesion is indicated, using the sialograms as a guide to direct the needle. This has been successful in diagnosing cystic salivary gland disease in 3 patients. The finding of a smooth walled cavity, the size of the sialographic circumscribed filling defect, is characteristic of this lesion (Fig. 15*C*). If aspiration is unsuccessful one can presume if the procedure was properly done that the tumor is cellular. Following successful aspiration, a centrally necrotic neoplasm, it is anticipated, will have irregular walls as shown analogously in renal tumors, according to puncture studies of Lindblom.[14] As a further precaution against concomitant malignant tumor the fluid should be studied by Papanicolaou method.

The infiltrative changes described by Blady and Hocker are due to advanced and extensive involvement of the salivary gland. Since normal acinar tissue has been destroyed by the neoplasm, there is total loss of the secretory function of the gland. This is noted in the lack of change in the bizarre pattern of the filling phase as long as 48 hours after stimulation (Fig. 16*B*). Some malignant growths give the appearance on sialograms in the filling phase of a circumscribed filling defect without showing evidence of adjacent duct destruction (Fig. 17*A*), but the surrounding parenchyma may be partially infiltrated. Since the infiltrative process replaced acinar tissue, an alteration in secretory activity and tissue permeability may occur. When the gland is stimulated, the radiopaque medium does not wash out of the duct system but appears to go into the surrounding acinar tissue (Fig. 17*B*).

Pathologic Correlation. It should be re-

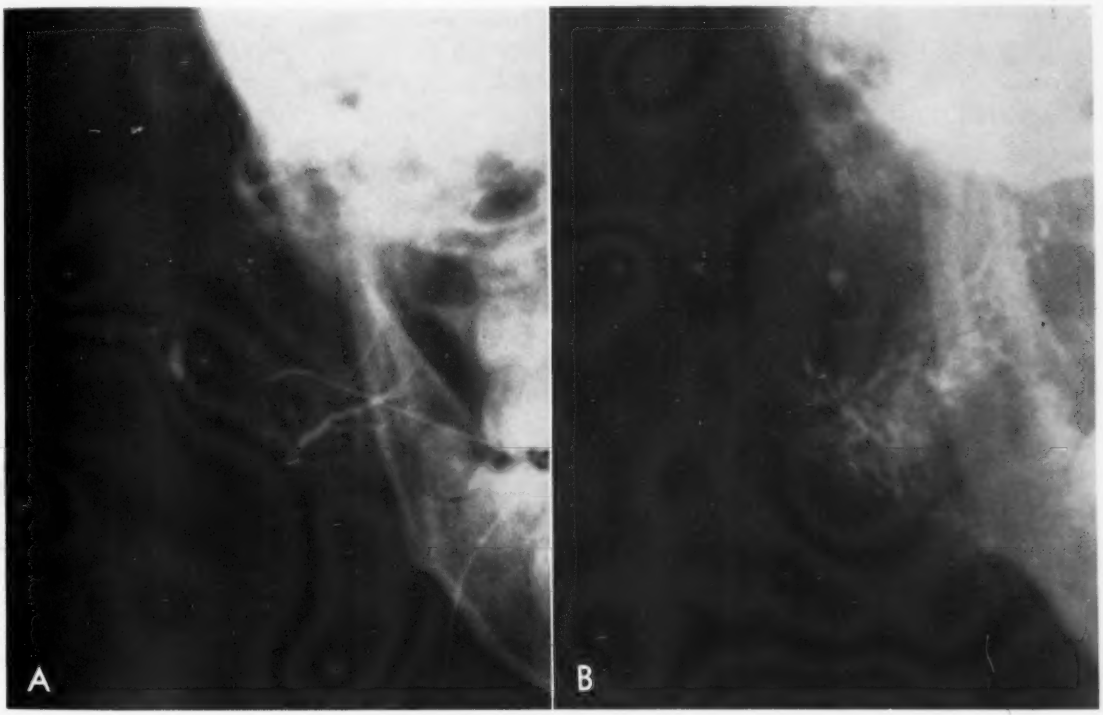

Fig. 17. Intrinsic invasive tumor: (*A*) There is a large mass in the right parotid gland displacing the duct architecture which, however, is preserved in the filling phase. (*B*) Following stimulation, the contrast material appears to have permeated the surrounding acinar tissue instead of being evacuated from the gland.

TABLE II

CLASSIFICATION OF SALIVARY GLAND TUMORS

Benign	Malignant
I. Mixed tumors	I. Malignant mixed tumors
II. Origin from ducts	II. Origin from ducts
1. Mucoepidermoid tumor	1. Mucoepidermoid carcinoma
2. Warthin's tumor (papillary lymphoid cystadenoma)	2. Squamous cell carcinoma
III. Origin from acinar tissue	III. Origin from acinar tissue
1. Serous cell	1. Serous cell adenocarcinoma
2. Mucous cell	2. Acidophilic gland cell carcinoma
3. Acidophilic cell	3. Mucus-forming carcinoma
IV. Supporting tissue	4. Pseudoadenomatous basal cell carcinoma (cylindroma)
1. Lipoma	IV. Supporting tissue
2. Fibroma	1. Liposarcoma
3. Hemangioma	2. Fibrosarcoma
4. Neurofibroma	3. Hemangioendothelial cell sarcoma
5. Lymphangioma	4. Neurofibroma

iterated that the radiologist reporting intrinsic tumors of the salivary gland should restrict himself to the terms encapsulated or circumscribed and invasive which are not synonymous with benign and malignant. No attempt should be made to diagnose the exact histologic type of salivary gland neoplasm on the basis of sialography. A recent review of 280 parotid tumors diagnosed and treated at the University of Michigan Hospital by Buxton, Maxwell, and French[6] illustrates this point, since 67 neoplasms previously reported as carcinomas were reclassified as benign. To appreciate the limitations of the sialographic approach to the problem, the complexities of pathologic diagnosis and classification are presented in Table II.

SUMMARY AND CONCLUSIONS

By correlative clinicopathologic and sialographic criteria, inflammatory diseases of the salivary glands may be classified as:

1. Chronic obstructive sialodochiectasis in which the abnormalities are primarily in the main duct. In this group, calculi and strictures are the principal pathogenic agents. Roentgenographically and histologically, the pathways which are dilated are the main duct and the interlobar and interlobular septal channels.

2. Chronic nonobstructive sialodochiectasis or sialectasis in which the abnormalities are principally in the peripheral ducts. This group is composed of heterogeneous but clinically related diseases which have a similar and characteristic pattern of "sialectasis." These entities include Mikulicz's disease, Sjögren's syndrome, recurrent pyogenic parotitis in adults and children. With the utilization of the filling and emptying phases of secretory sialography, the altered anatomicophysiologic pattern of sialectasis may be identified and classified into four stages: (a) punctate (early stage); (b) globular (moderately advanced stage); (c) cavitary (advanced stage); and (d) destructive (end stage).

3. The histologic changes of nonobstructive sialodochiectasis common to the aforementioned diseases correlate with and confirm the roentgen pattern of sparse, stenotic interlobar and interlobular ducts and dilated intralobular ducts.

4. Secretory sialography is valuable in identifying tumors extrinsic to the salivary glands since complete emptying of the duct system occurs immediately following stimulation of the glands to empty.

5. Intrinsic salivary gland neoplasms, however, show retention of contrast material in postevacuation films.

6. Neoplasms of the salivary glands, from the roentgenographic standpoint, are circumscribed or encapsulated and invasive. No attempt can be made to diagnose the histologic type of neoplasm by sialography.

7. The most consistent roentgen finding in circumscribed or encapsulated intrinsic neoplasms is a filling defect outlined by a displaced duct system. The general architectural pattern of the duct system is preserved. Retention of contrast material in postevacuation films is characterized by segmental intraglandular duct retention with differences due to the anatomic location and size of the tumor.

8. Infiltrative neoplasms characteristically show disruption of the gland architecture in the filling phase. The secretory phase shows retention of the contrast material where the acinar pattern is replaced by a bizarre puddling and pooling of the radiopaque material. Correlation with the histologic changes indicates that retention results because the normal acinar tissue has been destroyed or replaced by invasive neoplasm and the secretory function is lost.

9. An attempt has been made to renew interest in the procedure of sialography by suggesting techniques and interpretative data that have seemed to enhance its values and diagnostic aid.

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The authors wish to express their appreciation to the Department of Otolaryngology for its cooperation in supplying the clinical material, and to Dr. A. J. French of the Department of Pathology for reviewing the pathology slides.

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THE ROENTGENOLOGIC DIAGNOSIS OF ESOPHAGEAL VARICES*

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IN THIS age of improved surgical approaches in the problem of esophageal and gastric varices, the objective verification of their presence and the accurate determination of their anatomic extent assume increasing importance. The task of determining the presence or absence of varices usually falls on the radiologists' shoulders. Unfortunately, even if radiologists avail themselves of the best equipment and techniques, they are at best only able to show varices in about 30–50 per cent of those patients known to have them.

The author, conscious of his own lack of knowledge on this subject, a few years ago decided to develop a rational systematic method for studying those patients suspected of having esophageal varices. Currently available textbooks and recent literature contained very little regarding the technique of demonstrating varices, and when radiological colleagues were consulted they often expressed a desire to know more about varices and how to demonstrate them. Consequently, a diligent study of this problem was started.

Wolf[7] in 1928 first demonstrated esophageal varices roentgenologically by using thin barium. During the next decade much was learned about the demonstration of varices. The vast majority of factors affecting the roentgenologic demonstration of esophageal varices were already well known by 1931 when Schatzki[3] reviewed the subject of demonstrating esophageal varices and first described gastric varices. Schatzki[4] completely reviewed this subject in his classic monograph on relief studies of the diseased esophagus in 1933. Kegaries[2] and Rivers in 1933 added to our anatomic knowledge regarding the circulatory anatomy of the lower esophagus and proximal stomach. Templeton[5] summarized the subject in 1944 in his excellent textbook on the study of the esophagus, stomach and duodenum, but, unfortunately, this text is out of print and no longer available. The various factors affecting mediastinal physiology and intrathoracic venous pressures are well described in standard physiology textbooks.[1,6]

GENERAL ROENTGENOLOGIC TECHNIQUE

In order to slow the passage of barium through the esophagus, the patient should always be examined in recumbent position on a tilting fluoroscopic table which can be tilted into Trendelenburg position. When one also uses thick barium paste, the progress of the bolus is greatly slowed down, allowing more accurate and leisurely study to be made. The addition of 0.25 to 0.75 per cent of carboxymethylcellulose to the barium will further impede the passage of barium through the esophagus and also seems to enhance the adherent properties. In one patient the lower esophageal folds were still well outlined with carboxymethylcellulose barium ten minutes following the swallow. One milligram of atropine sulfate given subcutaneously thirty minutes before administering barium by mouth will often result in barium adherence on the mucosa for as long as one hour following the barium administration.

If radiologists avail themselves of the already known facts concerning the roentgenological diagnosis of esophageal varices and have the added advantages of modern roentgen generators, grids, intensifying screens, tilting fluoroscopic tables, and spot-filming devices, it should be possible to attain the highest accuracy in diagnosing varices, even those of minor degree. It goes

* From the Department of Radiology, Ohio State University, Columbus, Ohio. Presented at the Fifty-sixth Annual Meeting of the American Roentgen Ray Society, Chicago, Illinois, September 20–23, 1955.

without saying that fluoroscopically controlled spot-filming during visible filling of the varices or at optimum times during various maneuvers designed to demonstrate the less obvious cases will give the highest percentage of diagnoses.

ANATOMIC AND PHYSIOLOGIC FACTORS AFFECTING ROENTGENOLOGIC TECHNIQUE

The anatomic factors concerned with the formation of gastric and esophageal varices are well known and will only be briefly touched upon now. Figure 1 shows the important factors in portocaval circulation. It can be seen that any process which obstructs the portal flow through the liver or portal vein will cause hypertension in the venous system proximal to the obstruction. The vast amount of portal blood must, therefore, take an alternative route to the caval system via the gastric coronary vein, the vasa brevia, lower esophageal plexus, azygos system, and hence into the superior vena cava. Since the normal venous flow from the spleen is into the portal

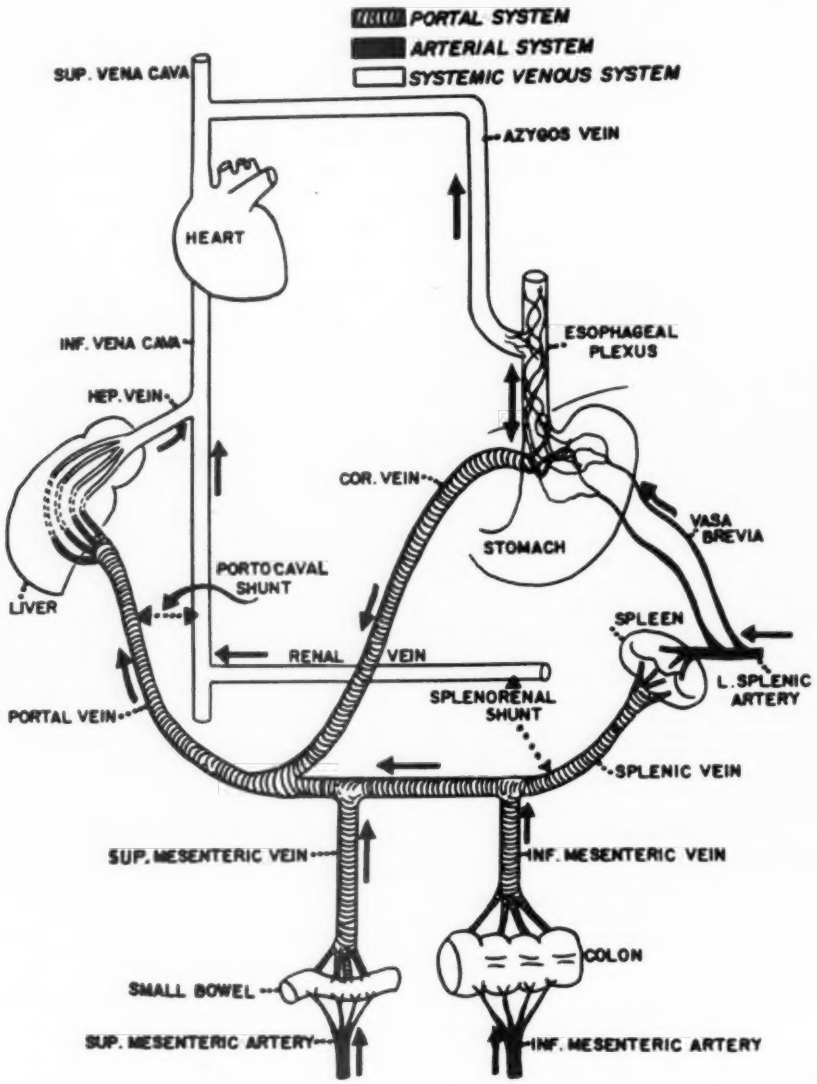

Fig. 1. Portal and systemic circulation. Solid arrow indicates normal direction of blood flow. Broken arrows indicate splenorenal and portocaval shunt operations.

vein, it is apparent that any process obstructing the splenic vein or intrasplenic venous flow will necessitate an alternative route to the caval system, primarily via the vasa brevia and lower esophageal plexus and hence into the superior vena cava, but possibly into the portal vein via the gastric coronary vein. It is also apparent from the diagrammatic drawing (Fig. 1) that lesions obstructing the superior vena cava or azygos system raise the venous pressure in the esophageal veins and reverse their blood flow into the portal system via the gastric coronary vein. Varices form because of the increased venous pressure and the abnormally large amounts of blood flowing through these smaller veins. From this diagrammatic drawing it can be understood why gastric varices so frequently accompany esophageal varices. Keeping these anatomic factors in mind, it is understandable that a diverse number of etiologic mechanisms are known to be the cause of varices. Cirrhosis of the liver and Banti's syndrome are by far the most important causes in our institution.

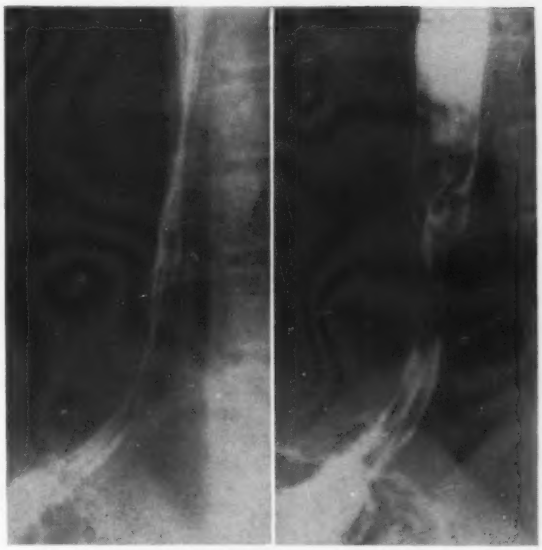

Fig. 3. Banti's disease. View on left shows contracted esophagus following passage of peristaltic wave—no varices apparent. View on right, made a few moments later during the Valsalva maneuver shows relaxed esophagus with very apparent large varices well demonstrated.

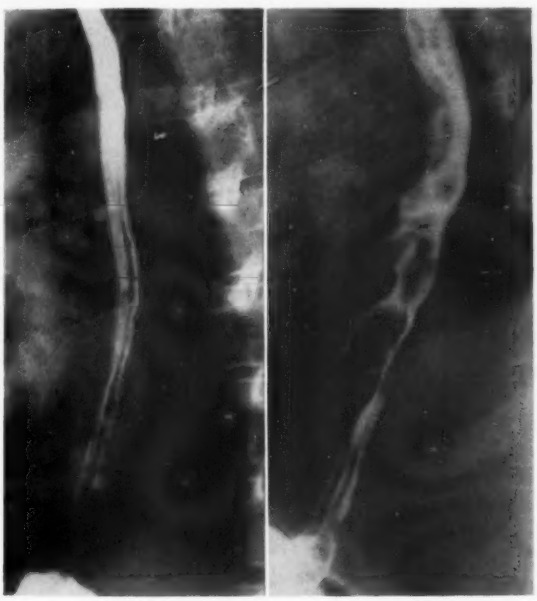

Fig. 2. Patient with Banti's disease. View on left shows esophagus in contracted state following passage of peristaltic wave which has apparently squeezed the blood out of the varicosities which are, therefore, not seen. View on right taken a few moments later during sustained Valsalva maneuver, during which the esophagus relaxes, thus allowing filling of the huge varicosities.

A good deal of our at best mediocre success in demonstrating gastric or esophageal varices depends upon our knowledge of the physiology of the esophagus and the various factors affecting the venous pressure in the abdomen and thorax. An understanding of the peristaltic activity of the esophagus and its effect upon varices is of much importance. We know that the segment of esophagus immediately distal to a primary peristaltic wave is in a relaxed state, whereas a long segment of the esophagus proximal to the progressing primary wave will remain contracted for many seconds if no further peristaltic waves are initiated. The contracted esophagus can force blood out of the loosely supported submucosal esophageal varicosities and render these roentgenologically nonvisible. Figures 2, 3 and 4 are examples of this important phenomenon. On the other hand, it is well known that in patients with esophageal varices the caliber of the lumen of the distal

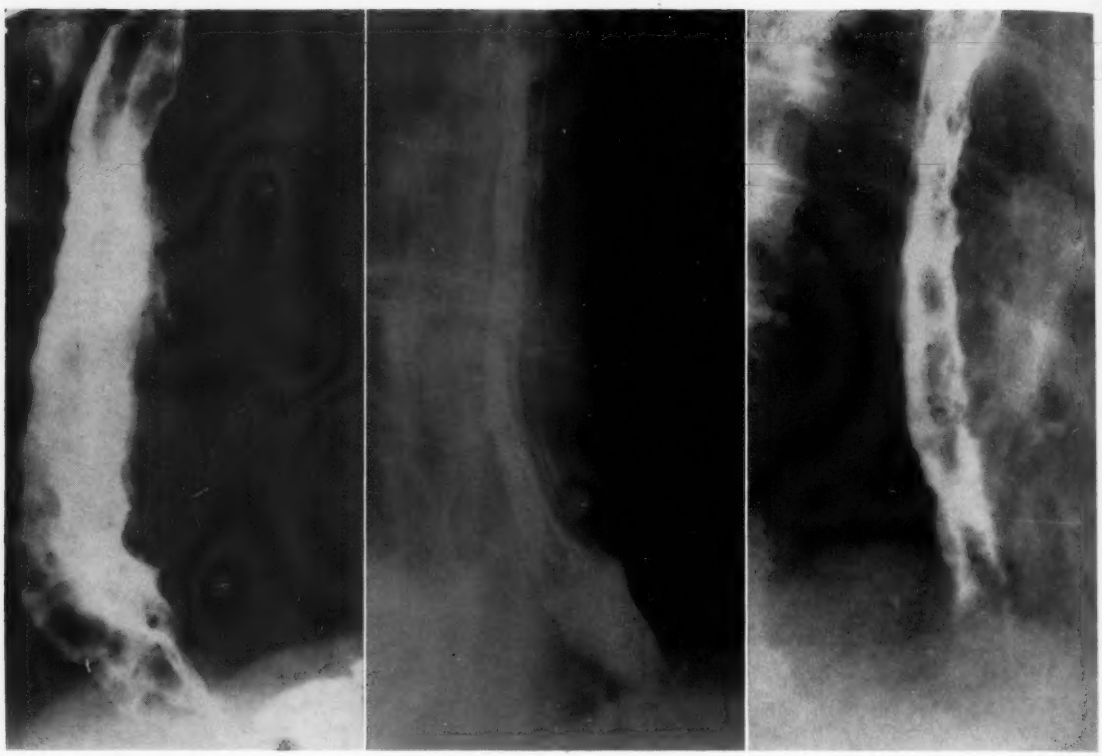

Fig. 4. Varices well shown in partly filled relaxed esophagus in view on left. In middle view peristaltic wave has squeezed blood out of varicosities which are, therefore, not seen. In view on right, taken a few moments later following swallow of thick barium, the varices are shown in a more relaxed esophagus.

esophagus is frequently greater than normal, possibly due to poor muscle tone and poor peristaltic activity. Consequently, if this large lumen is filled with a large bolus of barium, the varices are easily obscured (Fig. 5 and 6). Thus, we see that if we make films when the esophagus is too contracted or too full of barium we stand an excellent chance of failing in our attempt to visualize all but the most obvious cases.

We must now mention the role of the Valsalva maneuver. The maneuver is easily carried out by having the patient swallow a mouthful of ordinary barium-water mixture or a thicker mixture of such consistency that it cannot be poured from the spoon. Immediately after the patient swallows a mouthful of barium, he is instructed to "take in a deep breath, hold it in, and strain down hard as though trying to move your bowels or lift something heavy—keep straining, keep straining, don't breath, keep straining, don't breath," etc., until the varices become apparent or until the patient finally has to resume respiration. The maneuver often must be repeated several times and spot films made as late as possible during the maneuver, but before the patient resumes breathing. The Valsalva maneuver is important for three reasons:

1. During sustained Valsalva maneuver if the patient does not swallow, no further primary esophageal peristaltic waves are initiated and the esophagus, which remained contracted following the passage of the last primary wave, will eventually relax. Then the varices can fill and be shown if an optimum amount of barium remains in the lumen.

2. A second reason for relying upon the Valsalva maneuver is that it allows us to make unique use of the barium-retaining property of the distal esophagus, *i.e.*, the phrenic ampulla. During the Valsalva maneuver the primary wave ceases 3 to 5

cm. above the diaphragm and barium is retained in the ampulla. It is fortunate that the ampulla will retain a moderate-sized barium bolus during the Valsalva maneuver, because when relaxation occurs above the ampulla, the difference in intraluminal pressure between the ampulla and the relaxing esophagus allows barium to flow orally in small amounts into the relaxing lumen. Then, if the varices fill, they can be clearly shown by this reflux flow of small amounts of barium at just the right moment. Thus, by utilizing the phenomenon of retrograde flow of barium from the phrenic ampulla during sustained Valsalva maneuver, we are able to cope with those patients in whom the peristaltic wave "strips" the mucosa clean of barium. Figure 7 demonstrates rapid serial spot-filming of the emptying of a phrenic ampulla in a normal patient, and Figure 8 is a roentgenogram of a patient with varices in whom we made good use of the phrenic ampulla to demonstrate varices. Note how the varices are not shown on the *filled* view or while the esophagus is just starting to relax above the ampulla, but they are well shown later when esophageal relaxation and variceal filling have allowed the reflux barium filling to clearly delineate them.

3. A third, and the most widely known, although probably the least important reason for the use of the Valsalva maneuver in diagnosing varices, is that it supposedly increases the intra-thoracic and intra-abdominal venous pressure to the point where the varicosities will become engorged with blood. However, since the varicosities are submucosally located in the esophagus, esophageal muscular relaxation may be just as important, if not more important, than the increase in venous pressure. Peristalsis forces blood out of esophageal varices by obliterating the esophageal lumen. Thus, even if the venous pressure is raised during the Valsalva maneuver, it is probable that the varices will not fill and become recognizable until the space which they will occupy again becomes available when the heavily muscled esophagus relaxes.

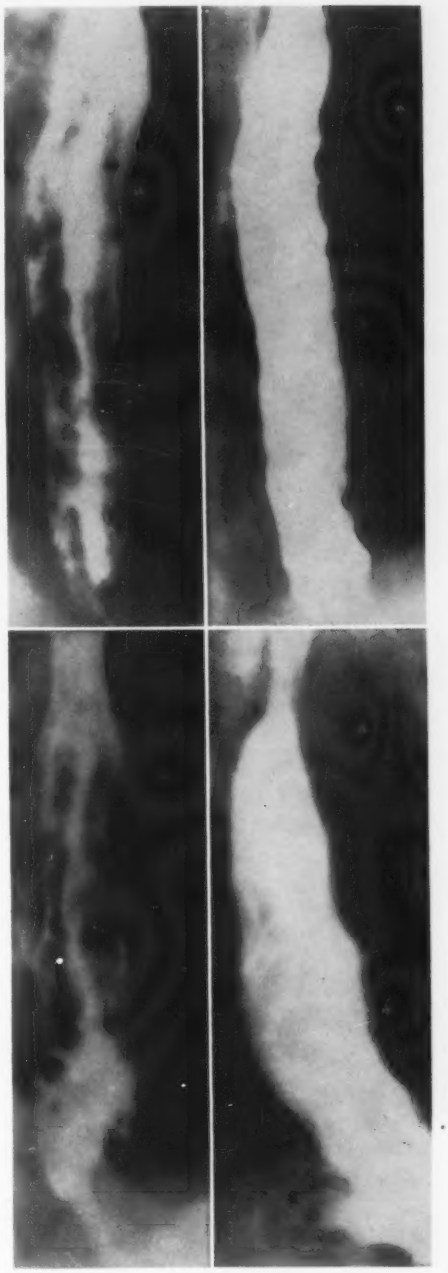

FIG. 5. Banti's disease. Top left view: Varices well shown in partly filled relaxed esophagus during Valsalva maneuver. Top right view: Varices not shown during Valsalva maneuver because there is too much barium in the lumen. Bottom left: Varices again shown during partly filled relaxed esophagus during Valsalva maneuver. Bottom right: The lower esophagus is relaxed and too full of barium; varices not shown. Note primary peristaltic wave which is entering the esophagus at upper end of this view.

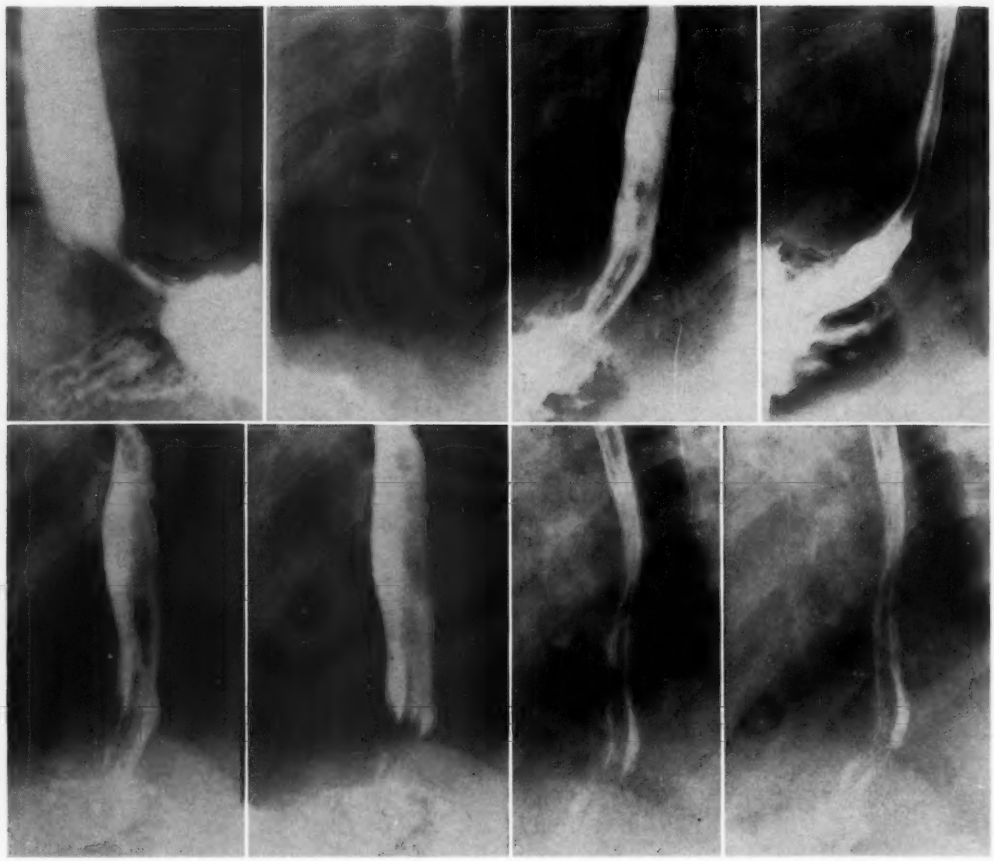

Fig. 6. Banti's disease. Top left: Varices obscured by too much barium. Top second from left: Too little barium. Top third from left: Varices barely seen through barium. Top right: Right amount of barium but esophagus in contracted state and varices not well demonstrated. Bottom left: Varices seen through fairly large amount of barium. Bottom second from left: Too much barium but varices seen through it. Bottom two right-hand views: Optimum amounts of barium in partially relaxed esophagus show the varices well.

However, the relative importance of increased venous pressure or esophageal relaxation is of academic interest because both of these phenomena are enhanced by the Valsalva maneuver. Varices often increase in size during the Valsalva maneuver (Fig. 9).

It must also be mentioned in passing that the Valsalva maneuver occasionally results in poor visualization of esophageal varices, whereas shortly following discontinuation of the maneuver the varices fill. The explanation for this relatively rare phenomenon is not definitely known, but it seems reasonable to assume that during the Valsalva maneuver the esophageal veins at the level of the hiatus are compressed by the pinch-cock effect of the diaphragm Thus, if a previous peristaltic wave has partly emptied the varicose veins, it is possible that the pinch-cock effect could occur before the venous blood from the abdomen could flow into the lower esophageal plexus.

Occasionally the Müller maneuver will result in demonstration of esophageal varices when all other methods have failed (Fig. 10). The Müller maneuver is accomplished by asking the patient to swallow the mouthful of barium and then instructing the patient to "blow your breath all out, pinch your nose, close your mouth and try to suck in air as though trying to pull it in through your ears."

The maneuver is done during expiration and the high position of the diaphragm will cause the esophagus to become slack, resulting in some tortuosity of the normal folds which may occasionally be misinterpreted as varices. Varices are more serpiginous, wider, and more nodular than tortuous normal folds. The radiologist can best learn what tortuous folds look like by taking films of the lower esophagus during the Müller maneuver on patients not suspected of having varices.

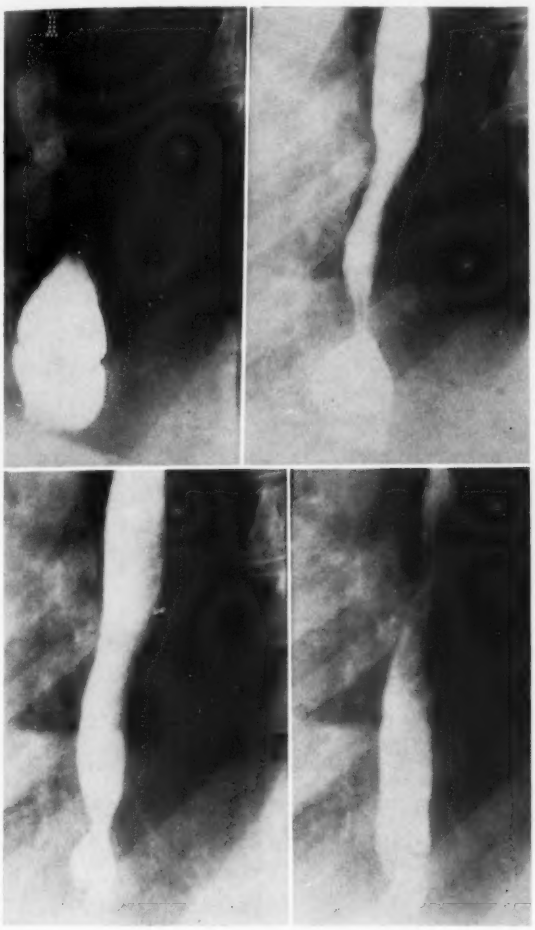

Fig. 7. Phrenic ampulla. Rapid serial spot roentgenograms during the Valsalva maneuver. Top left: Peristaltic wave has forced barium into the phrenic ampulla. Top right: Approximately one second later the esophagus above ampulla has relaxed and barium has begun to flow rapidly retrograde. Bottom left: Approximately one second after top right view; now almost all barium has passed from ampulla into lower esophagus. Bottom right: Approximately one second after bottom left view; ampulla no longer apparent; complete relaxation above ampulla.

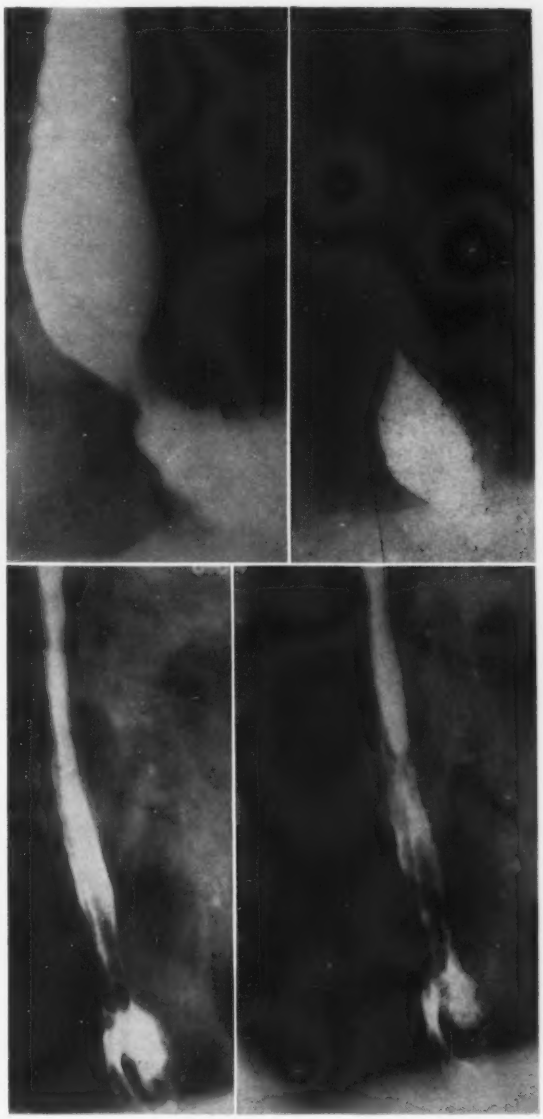

Fig. 8. Portal cirrhosis. Top left: Too much barium in relaxed esophagus. Varices not shown. Top right: During sustained Valsalva maneuver, small amount of barium beginning to flow retrograde into lumen of esophagus, which is just beginning to relax. Varices not yet shown. Bottom left and bottom right: These views taken later during the Valsalva maneuver show varices, with optimum amounts of barium in partly relaxed esophagus above phrenic ampulla.

Varices in the abdominal portion of the esophagus are almost never demonstrable because of the aforementioned anatomic

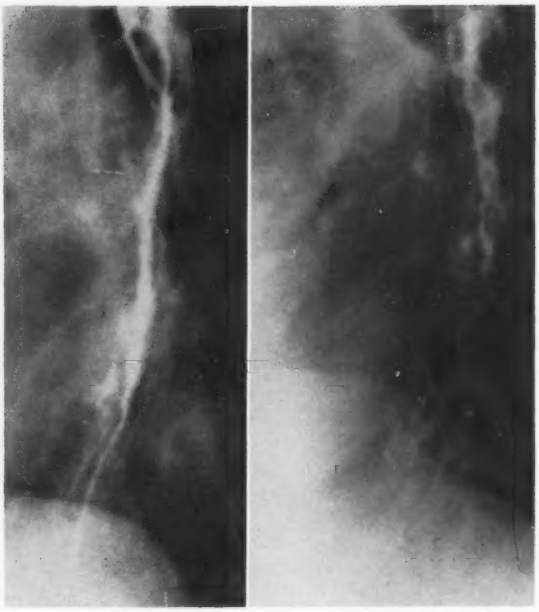

Fig. 9. Banti's disease. View on left: Barium clinging to mucosa of relaxed esophagus before Valsalva maneuver does not very clearly show varices. View on right: During sustained Valsalva maneuver the varices are clearly shown.

factors, *i.e.*, stronger support in submucosa, thicker walled veins, and compressing effect of the diaphragm. However, by avoiding the use of the Valsalva maneuver, varices in this location can occasionally be shown (Fig. 12), as in this patient with both esophageal and gastric varices.

Although many cases of varices require the employment of the aforementioned techniques for their demonstration, a number can still be easily demonstrated because of their constant distention and large size. In one case (Fig. 11) the varicosities extended the entire length of the esophagus and were easily demonstrable without any special effort—the patient merely swallowed a mouthful of thick barium and the varices could be shown.

If one so desires, one can get good air views of the esophagus if he is able to get barium to remain in the lumen by the aforementioned use of thick barium paste or carboxymethylcellulose barium or atropine. Following this, the patient is given simultaneously from two different teaspoons a few cubic centimeters of citric acid and sodium bicarbonate, which are then swallowed in one gulp and the patient instructed to refrain from further swallowing and belching. By the use of the Trendelenburg position the gas moves "uphill" toward the stomach, whereas in the semi-Fowler's position the peristalsis moves the gas "downhill" at a slower pace. By using the Valsalva maneuver, the same physiologic factors influence the visualization of varices as when positive contrast is used. I have not found that air views have improved the demonstration of varices.

GASTRIC VARICES

Gastric varices should always be searched for whenever esophageal varices are suspected because they are so commonly present and are frequently the cause of severe bleeding. From the anatomic diagram (Fig. 1) it is understandable why gastric varices are so common; indeed, one wonders why they do not always precede the esophageal varices. The explanation lies in the fact that the veins in the region of the cardia and abdominal portion of the esophagus are better supported by connective tissue in the submucosa and are thicker walled than the thin-walled, loosely supported veins in the submucosa of the esophagus above the diaphragm.

No special techniques are necessary for the demonstration of gastric varices. A good fluoroscopic table capable of tilting into Trendelenburg position plus the diligent filming of the proximal stomach immediately following the change from supine to prone position will frequently show the gastric varices clearly. Figure 13 is an example of esophageal and gastric varices occurring simultaneously. We have had a few instances in which the most diligent effort failed to show esophageal varices, although the gastric varices were easily shown. When this occurs, the differential diagnosis between gastric varices and neoplasm is impossible. However, gastric varices are usually so sharply defined and scalloped-appearing that the true diag-

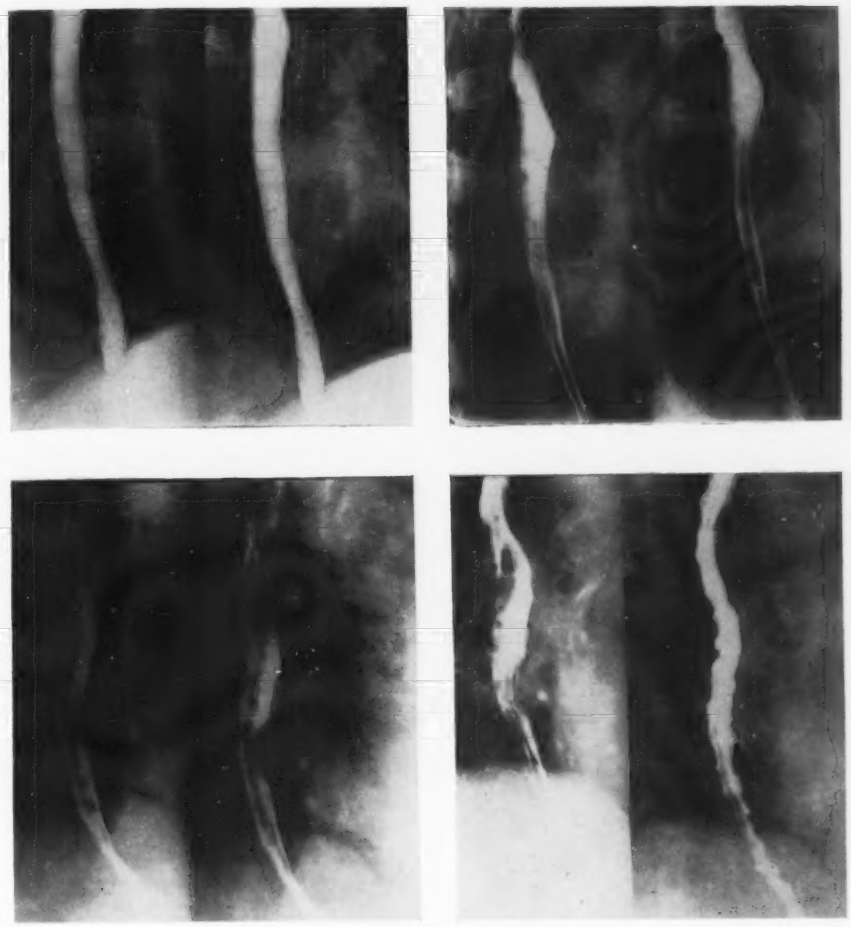

Fig. 10. Value of Müller maneuver. Two top left views: During sustained Valsalva maneuver varices not shown. Two lower left views: During sustained Müller maneuver varices shown. Two top right views: Two days later, same patient. During sustained Valsalva maneuver varices not shown. Two bottom right views: A few moments later during Müller maneuver the varices are well shown.

nosis can be strongly suspected. Figure 14 is a case in point. Note the smooth-appearing lower esophagus and the large soft tissue mass in the cardia of the stomach. Note, also, how the large gastric varices are completely obscured by barium in the filled view but are clearly shown by air contrast views.

FOLLOW-UP STUDIES AFTER SURGICAL PROCEDURES

I have performed several follow-up examinations following various surgical procedures for the alleviation of the serious bleeding problem in patients with esophageal varices. In patients with Banti's disease, splenectomy alone sometimes results in some diminution in size of the varicosities and often alleviates the bleeding even if the varices do not diminish in size. The ligation of the vasa brevia and gastric coronary vein is now almost always done in addition to the splenectomy, and occasionally a proximal gastric resection is done if gastric varices are present. It is in cirrhotic patients with varices that the results of surgery were most dismal until the advent of portocaval and splenorenal shunt operation. From the anatomic diagrammatic drawing (Fig. 1) it is understandable why splenectomy is of no value in cirrhotic patients and why injection of

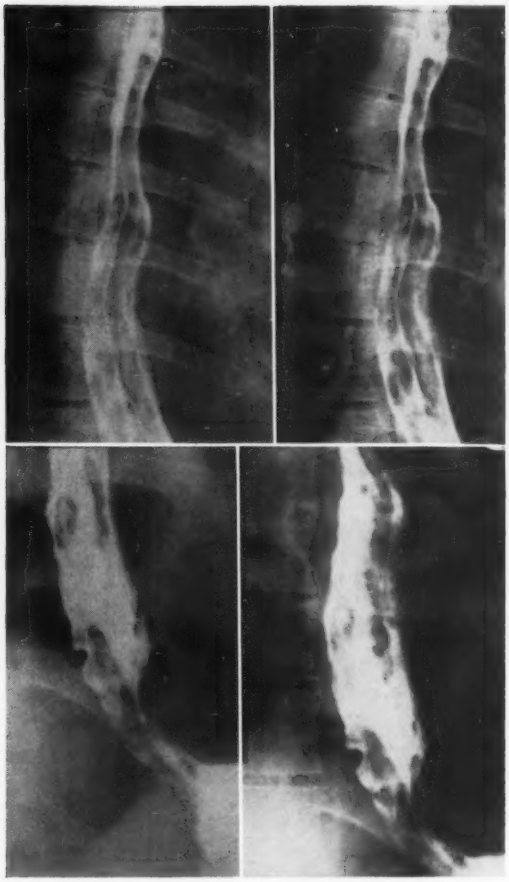

Fig. 11. Banti's disease. Varices easily demonstrated following swallow of thick barium without use of Valsalva maneuver. Two top views: Varices shown in upper esophagus above level of aortic arch. Two bottom views: Large varices shown in lower esophagus.

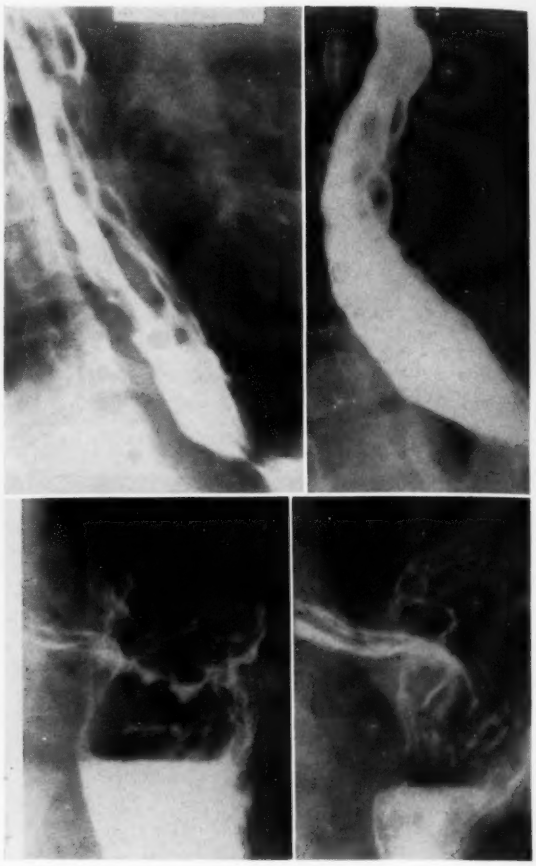

Fig. 13. Esophageal and gastric varices in patient with portal cirrhosis. Gastric varices best shown by mucosal relief technique, which demonstrates varices by virtue of several semilunar shaped scalloped-appearing collections of barium in the gastric fundus.

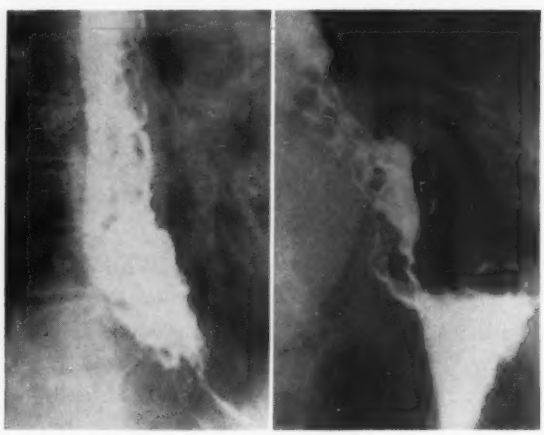

Fig. 12. Portal cirrhosis. Esophageal varices and gastric varices. Of particular interest are the obvious

sclerosing solutions and partial proximal gastric resections are largely unsuccessful in controlling bleeding. Figures 15 and 16 represent two cirrhotic patients who underwent splenectomy and splenorenal shunt operations because of extensive esophageal varices which were bleeding. Note the rather dramatic diminution in size in the first case and the complete disappearance

varices in the abdominal portion of the esophagus. Templeton[5] states that he has never observed them there. The above right-hand view was not made during Valsalva maneuver, but was made during suspended quiet respiration following passage of a bolus of barium in the up-right position.

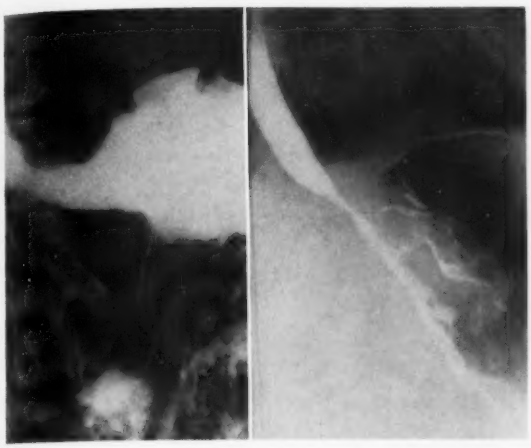

Fig. 14. Portal cirrhosis. View on left: No varices seen in barium-filled gastric fundus or lower esophagus. View on right: Using mucosal relief technique, huge varices are demonstrated. Differential diagnosis between varices and neoplasm would be impossible. Surgery disclosed huge gastric varices. Autopsy showed numerous small esophageal varices which we had never been able to demonstrate on numerous examinations.

of all evidence of varices in the second case as manifested by our failure to show varices after diligent and exhaustive effort on several occasions for over a year following surgery.

SUMMARY

The various factors which are of importance in demonstrating esophageal and gastric varices have been discussed. If the following factors are kept in mind during the study of patients suspected of having esophageal and gastric varices, the highest possible degree of diagnostic accuracy will be attained:

1. Recumbent and Trendelenburg position should be used.

2. Thick barium mixtures are preferable, although various thinner mixtures will often suffice.

3. Carboxymethylcellulose in 0.25– 0.75 per cent mixed with ordinary barium mixtures will improve the adherence of the barium to the esophageal and gastric mucosa.

4. Atropine sulfate in doses varying from 0.5 to 1.0 mg. subcutaneously thirty minutes before the examination will also increase the adherency of the barium to the mucosa.

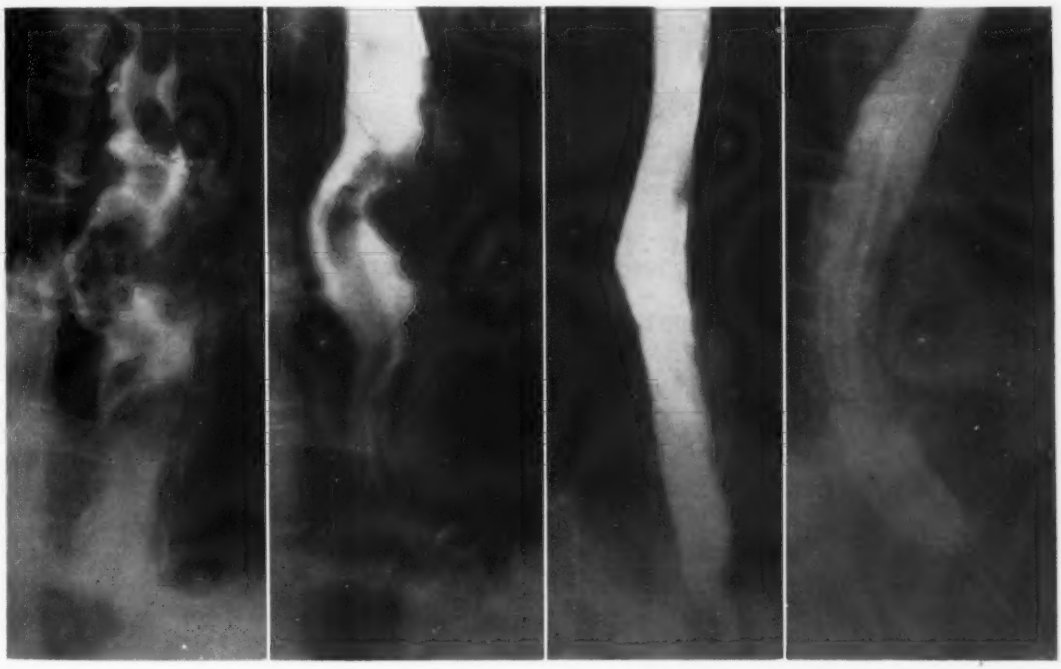

Fig. 15. Portal cirrhosis. Two left-hand views: Huge varices shown prior to surgery. Two right-hand views: Varices could not be demonstrated three weeks following splenorenal shunt.

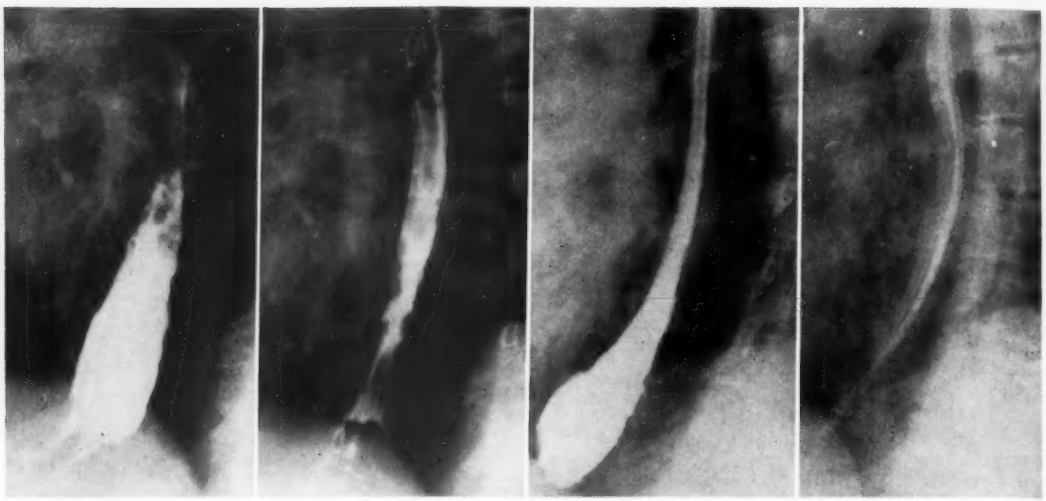

Fig. 16. Two left-hand views: Varices obvious before surgery. Two right-hand views: In spite of repeated diligent efforts, varices not demonstrable one year following splenorenal shunt operation.

5. Multiple fluoroscopically controlled spot roentgenograms are necessary in varying positions because smaller varices will often only be shown in one projection.

6. Esophageal peristalsis is very powerful and a peristaltic wave can obliterate the varices. Under fluoroscopic control esophageal relaxation can be observed and the esophagus roentgenographed in a more relaxed state during which the varices usually fill.

7. The Valsalva maneuver properly performed is usually of great value in demonstrating varices, probably because during the sustained Valsalva maneuver (if the patient does not swallow) no further primary peristaltic waves are initiated and the esophagus will eventually relax.

8. Venous pressure will usually increase during the Valsalva maneuver and this, too, is felt to play a role in the visualization of the varices during this maneuver.

9. The phrenic ampulla, if present, can be of great value during the sustained Valsalva maneuver because the pinch-cock effect of the diaphragm can trap barium in the ampulla during the progression of the primary peristaltic wave towards the distal esophagus. If the Valsalva maneuver is sustained, esophageal relaxation will occur and allow small amounts of barium to flow retrograde into the relaxing esophagus and thus demonstrate the varices at an optimum time during their filling.

10. The Valsalva maneuver will frequently prevent the visualization of varices in the lower esophagus because the pinch-cock effect of the diaphragm during the maneuver is felt to prevent filling of the varices from the abdomen. By discontinuing the maneuver for three or four seconds, the varices may fill and then be properly roentgenographed.

11. In order to demonstrate varices in the abdominal portion of the esophagus, respiration should be suspended comfortably in the expiratory phase. The Valsalva maneuver will obliterate varices in the abdominal portion of the esophagus.

12. The Müller maneuver will occasionally show varices when all other methods have failed.

13. Too much barium in the esophageal lumen will frequently obscure even large varices. Relief techniques using smaller amounts of barium are much more likely to demonstrate even the smaller varices.

14. The radiologist's chances of demonstrating varices of the esophagus will be markedly diminished if the patient is ex-

tremely ill (orthopnea, ascites, shock, etc.) or irrational and uncooperative.

CONCLUSION

Improving surgical techniques for the alleviation of bleeding from esophageal and gastric varices justify a more diligent approach in demonstrating varices as early as possible in those patients suspected of having them. If the examiner uses ordinary or thick barium mixtures and concentrates on mucosal relief techniques in addition to utilizing the already known factors concerning circulatory anatomy, esophageal physiology, and venous physiology, he will demonstrate varices in the highest possible number of cases. The author has not discussed the demonstration of esophageal and gastric varices by means of splenoportography. Rather he has limited his discussion to methods and techniques available to all radiologists engaged in performing conventional gastrointestinal roentgenologic examination, whether in the private office or in the hospital.

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A ROENTGENOLOGIC STUDY OF ULCERATING LESIONS OF THE STOMACH*

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FOR many years, clinicians were taught to consider all ulcers appearing on the greater curvature of the stomach, or those measuring greater than 2.5 to 4.0 cm. in diameter, as malignant until proved otherwise. Although less attention has been directed toward prepyloric lesions, this area has also been defined as a zone in which the differentiation between benign and malignant ulceration was difficult, if not impossible.

Alvarez and McCarty[2] studied 638 cases of gastric ulcer subjected to surgery, and in an article published in 1928, inferred that two thirds of the lesions which could not be covered by a twenty-five cent piece (a coin exactly 2.5 cm. in diameter) would be malignant and that all of those lesions of 4.0 cm. or more in diameter would undoubtedly be malignant. Since this early report, however, several authors have reported "giant" benign gastric ulcers. In 1953, Shoulders and Lischer[6] published an account of 7 cases of benign gastric ulcers, all of which were over 6 cm. in diameter. In 1941, Allen and Welch,[1] in reviewing a series of gastric ulcers removed surgically, reported 100 per cent of the greater curvature ulcers as malignant. Subsequently, Welch and Allen,[8] reported 6 benign greater curvature ulcers surgically removed between the years 1938 and 1947. This prompted revision of their previous conclusions as to location and malignancy.

As late as 1945, Lahey[4] stated that he had never observed a benign greater curvature gastric ulcer. However, Boudreau and co-workers,[3] in 1951, described 47 greater curvature gastric ulcers discovered at autopsy, and 24 or 51 per cent of these were histologically benign. Silk and associates,[7] in 1953, reported on 18 greater curvature gastric ulcers, 8 of which proved to be benign.

Accordingly, it seemed appropriate to examine our experience with respect to the relative frequency of benign and malignant lesions appearing in these three categories, and to re-evaluate the precision of the roentgenologic diagnosis of such lesions. This study is based upon all patients with histologically proved, roentgenologically detectable ulcerating lesions of the stomach examined at the Mallinckrodt Institute of Radiology between the years 1947 and 1955. A total of 191 such cases were available for study.

Those patients with nonulcerative, polypoid or infiltrative growths have been excluded. Ulcers that were observed during treatment to heal and disappear were not included. The diagnosis proposed at the time of the initial roentgen examination was the only one used for this statistical survey. It is of interest to note that in a few cases, however, repeated examination revealed healing and disappearance of a lesion diagnosed as benign only to have it later reappear, exhibit malignant characteristics, and prove to be histologically malignant.

Of the 191 proved cases, 90 patients had lesions which were either larger than 2.5 cm. in diameter or were located in the prepyloric region or on the greater curvature of the stomach. This group of 90 cases is the principal basis of this report. The remaining 101 cases of confirmed ulcerating lesions from other areas of the stomach are presented for comparison.

GREATER CURVATURE GASTRIC ULCERS

Included in this group were all ulcerating lesions appearing on the greater curvature

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of the stomach as projected on the postero-anterior profile of the barium filled stomach. This definition, as described by Palmer,[5] is thought to represent a valid reference since visualization of ulcers roentgenographically in this area would actually place them within 1 cm. of the omental origin of the greater curvature. Ulcerations situated within 2.5 cm. of the pyloric canal were listed separately under the heading of prepyloric lesions. Size of the ulcer in this greater curvature group was disregarded.

The 12 patients with histologically proved greater curvature ulcers are listed in Table 1. Of these 12, 6 were benign and 6 malignant. The roentgenologic diagnosis of benign gastric ulcer was proposed in 5 instances. Histologic examination of the resected specimens proved this to be correct in 4 cases and incorrect in 1. The roentgenologic diagnosis of malignancy was considered in 7 instances and subsequently proved correct in 5 and incorrect in 2.

Roentgenograms of a typical benign greater curvature ulcer are shown in Figure 1. There was an excellent demonstration of mucosal folds radiating into the ulcer, and the ulcer projected well beyond the gastric margin. These signs clearly point toward benignity in spite of the location of this lesion. Histologic examination confirmed this impression. In contrast, the next illustration (Fig. 2) exhibits a moderately large ulceration appearing in a large filling defect on the greater curvature. Radiation of mucosal folds could not be demonstrated and the ulcer did not project beyond the gastric margin. The roentgenologic diagnosis of malignant ulcer proved to be correct.

Two cases in which an incorrect roentgenologic diagnosis was made were quite similar in appearance. The first was a thirty year old man with a large ulcer high on the greater curvature of the fundus of the stomach (Fig. 3). The mucosal folds in the vicinity of the ulcer were neither distorted nor disrupted. Because of the patient's age and the roentgen appearance of the lesion, it was felt that this represented a benign ulcer. Histologic examination, however, revealed adenocarcinoma with involvement of regional lymph nodes. Except for the associated deformity of the stomach present in the second case (Fig. 4), the ulcer was not unlike that shown in Figure 3. Since this case appeared soon after the first error, a roentgen diagnosis of malignancy was made. Pathologic examination, however, revealed a chronic benign ulcer.

Table 1

GREATER CURVATURE GASTRIC ULCERS

	Roentgen Diagnosis	Histologic Diagnosis	
	No. of Cases	Benign Cases	Malignant Cases
Benign	5	4	1
Probably benign	0	0	0
Probably malignant	1	1	0
Malignant	6	1	5
Total	12	6	6

GIANT GASTRIC ULCERS

The "giant" ulcer is more difficult to define. It is impossible to choose a single crater diameter as that one which satisfactorily divides ulcerating lesions into the two categories of small and large. Previous reports have selected diameters ranging from 2.5 to 6.0 cm. as the line of division.[2] In order to be all inclusive, the smaller diameter was selected as the initial point of reference.

We collected 49 patients with histologically confirmed ulcerating lesions of the stomach in which the ulcer crater measured at least 2.5 cm. in diameter at the time of roentgenologic examination (Table II). Of these 49 cases, 31 were subsequently proved to be benign and 18 malignant. Two diagnostic errors occurred among the 26 cases roentgenologically diagnosed as benign, one in the same patient previously illustrated under greater curvature ulcers. Seven benign ulcers were mistakenly diagnosed as

Fig. 1. Male, aged forty-eight, with a greater curvature gastric ulcer diagnosed roentgenologically and histologically proved benign. Radiating mucosal folds are well demonstrated.

malignant at the time of roentgenologic examination while a correct roentgenologic interpretation of malignant ulcer was made 14 times. This rather high error may reflect, in part, the influence of the previously accepted dictum regarding ulcer size. At any rate, many feel that errors in this direction cannot be seriously condemned since they usually lead to further study or exploratory laparotomy. Of the two largest ulcers, both greater than 7 cm. in diameter, one was benign and one malignant. The benign ulcer, mistakenly diagnosed as malignant, is shown in Figure 5. The great size and large radiolucent filling defect about its base led erroneously to the diagnosis of lymphosarcoma. The presence of radiation of mucosal folds toward the ulcer crater was ignored. Good demonstration of radiating mucosal folds (Fig. 6) is good evidence of benignity.

Fig. 2. Roentgenologically diagnosed malignant greater curvature gastric ulcer in a male, aged sixty-nine, histologically confirmed.

Table II

"GIANT" GASTRIC ULCERS
Diameter greater than 2.5 cm.

	Roentgen Diagnosis	Histologic Diagnosis	
	No. of Cases	Benign Cases	Malignant Cases
Benign	22	20	2
Probably benign	4	4	0
Probably malignant	3	1	2
Malignant	20	6	14
Total	49	31	18

Note that the radiating folds are apparent in the oblique projection and were not seen in a supine anteroposterior projection. Overhanging edges of the ulcer crater, as demonstrated in a prepyloric ulcer (Fig. 7), also point toward a benign lesion. A radiolucent "collar," as demonstrated in Figure 8, may be due to inflammatory infiltration about the ulcer crater and is quite common with large benign ulcers. The presence of such a

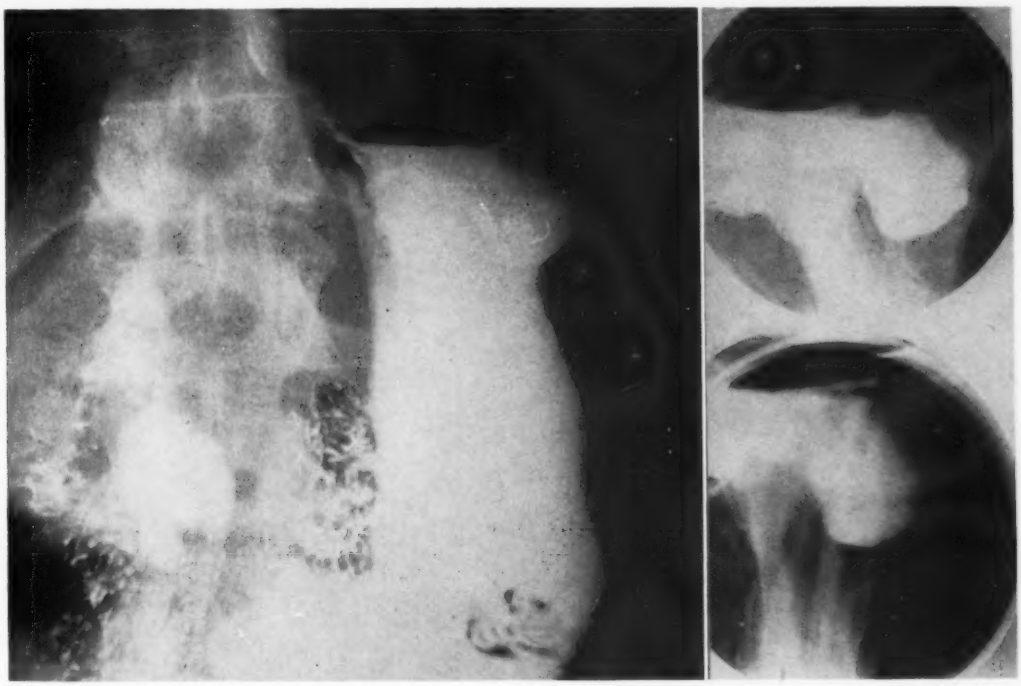
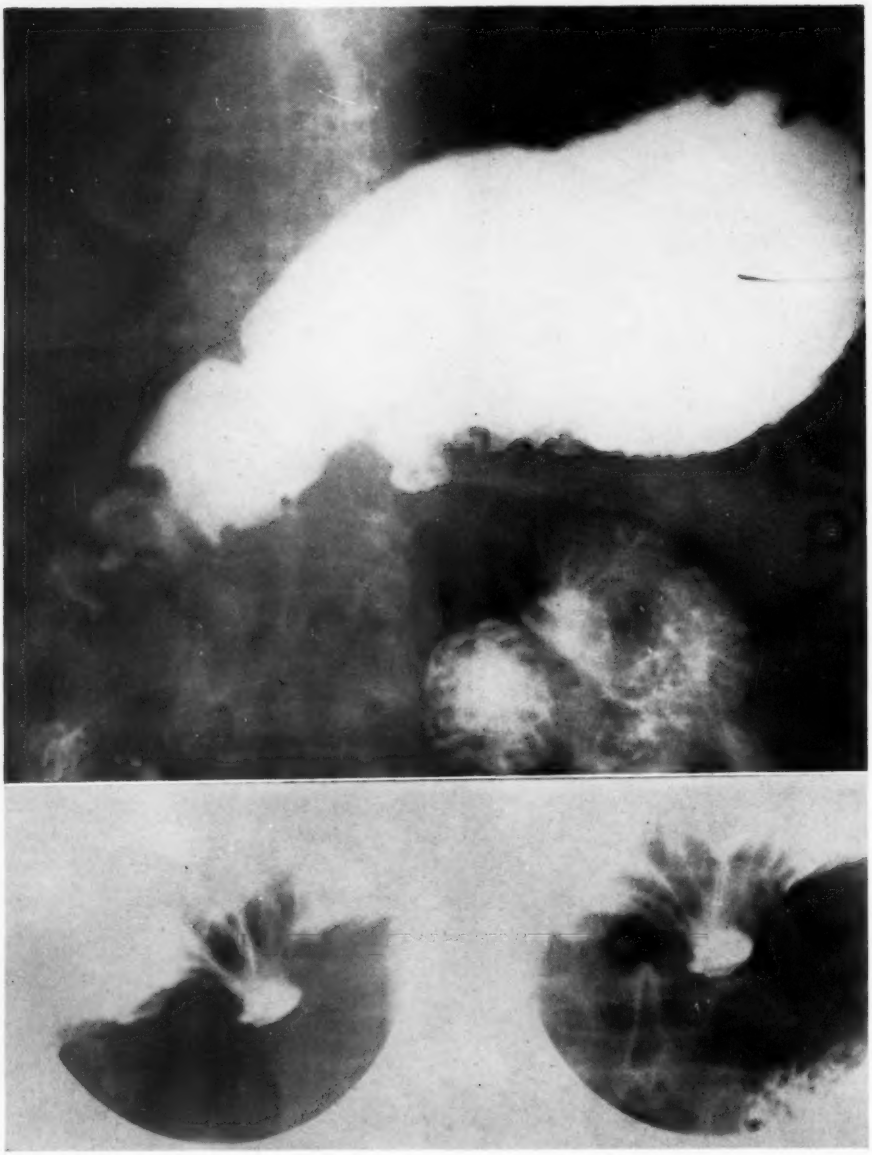


Fig. 3. Thirty year old white male with malignant greater curvature gastric ulcer located at the fundus. This was roentgenologically called benign probably because of intact adjacent mucosal folds.



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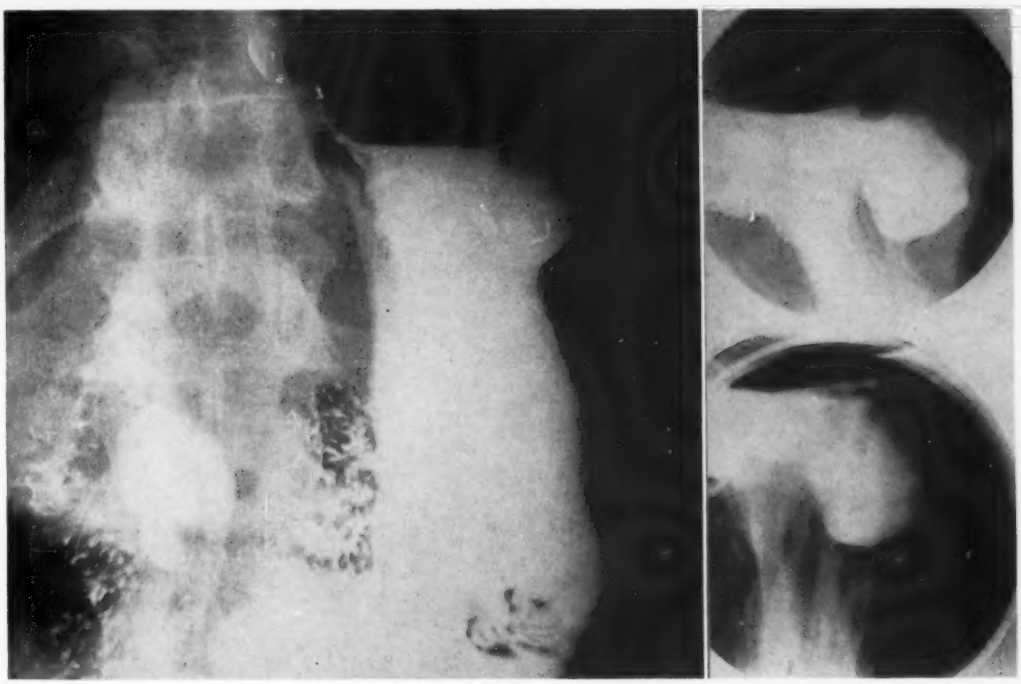

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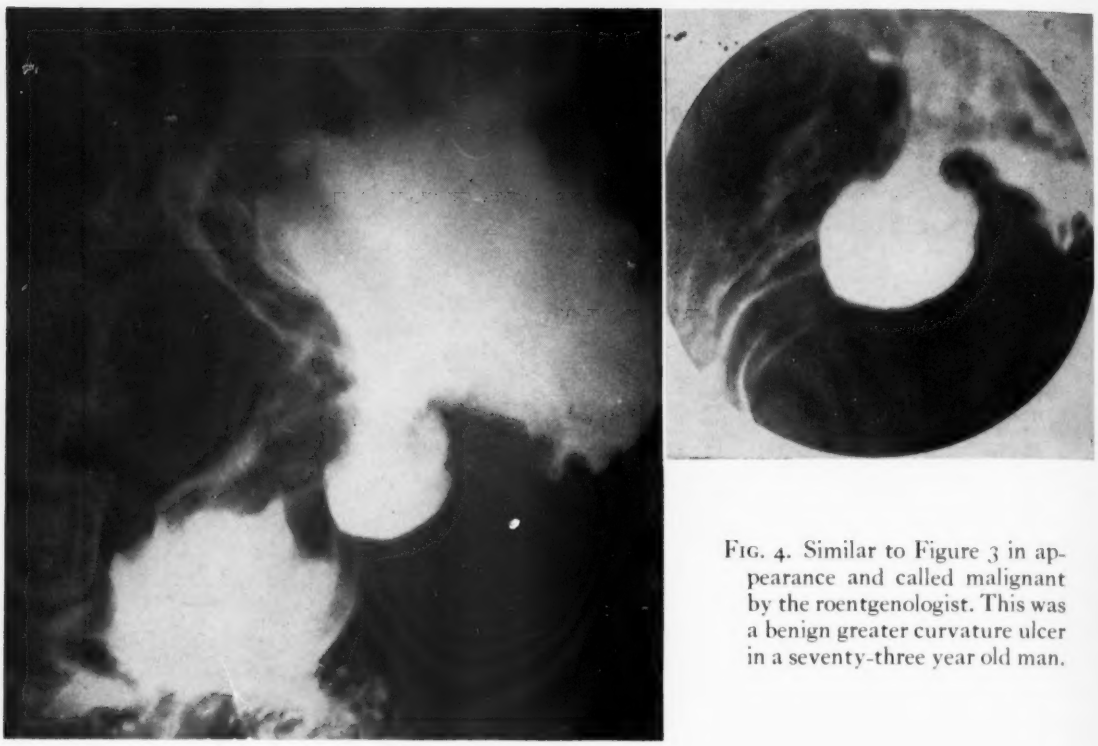

Fig. 4. Similar to Figure 3 in appearance and called malignant by the roentgenologist. This was a benign greater curvature ulcer in a seventy-three year old man.

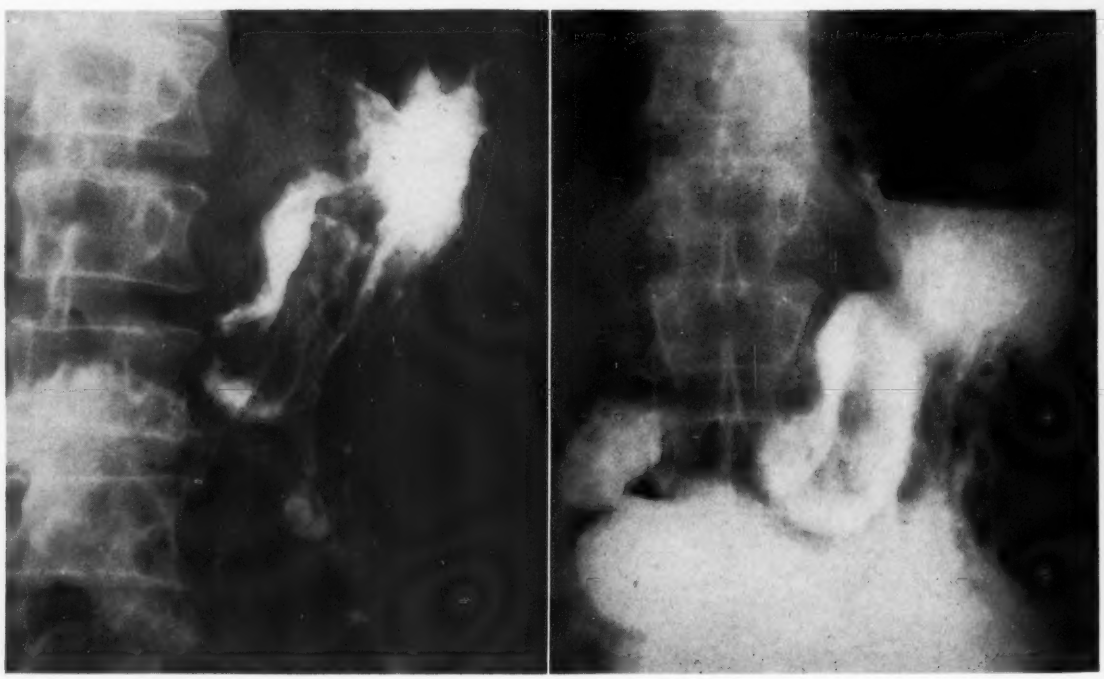

Fig. 5. A histologically benign "giant" ulcer, roentgenologically misdiagnosed as malignant, present in a male aged fifty-five. Note the large filling defect about the base of the ulcer.

regular smooth "collar" should not be used as a point in favor of malignancy.

The typical large malignant ulcer is represented by Figure 9. The crater lies within a larger tumor mass and does not project beyond the gastric margin. Mucosal folds about this area are not demonstrable.

If selection of giant ulcers is based upon a 4 cm. diameter, only 16 histologically proved cases may be included. Of these, 8 were benign and 8 malignant. Curiously, 4 of these malignant ulcers proved to be sarcomas rather than carcinomas. Whether this apparent high incidence of sarcoma among the largest ulcers is of statistical significance must await further evidence.

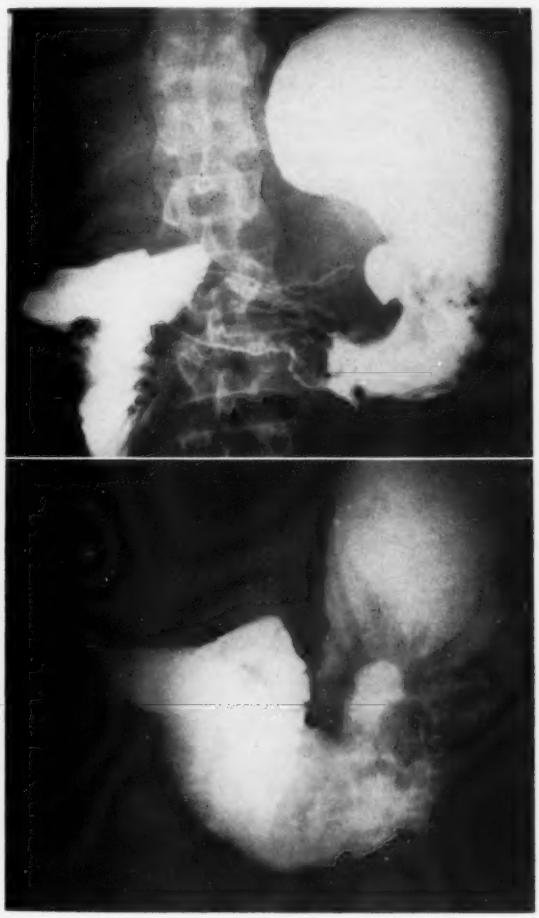

Fig. 6. Radiating mucosal folds are emphasized at the base of a benign gastric ulcer found in a man aged forty-five. The roentgen diagnosis was confirmed histologically

Fig. 7. Overhanging edges are often a sign of benignity as they were in this histologically confirmed prepyloric gastric ulcer in a male aged forty-six.

PREPYLORIC ULCERS

Last to be discussed are the prepyloric ulcers. This group includes all cases with lesions located within the 2.5 cm. of the stomach proximal to the pyloric canal regardless of size or curvature location. As previously mentioned, the prepyloric location was given preference in grouping over the greater curvature. Using this definition, we have collected 37 histologically proved cases (Table III). Of these 37, 29 proved to be benign and 8 malignant. One error was found in the 23 lesions diagnosed as benign roentgenologically, and an erroneous diagnosis of malignancy was made in 7 of 14 instances. This represents a somewhat larger error than in the groups previously discussed, but again is in the proper direction. We do not feel that the explanation lies entirely with mistaken reliance on the significance of location. However, the prepyloric stomach, being of relatively small dimensions, lends itself readily to greater

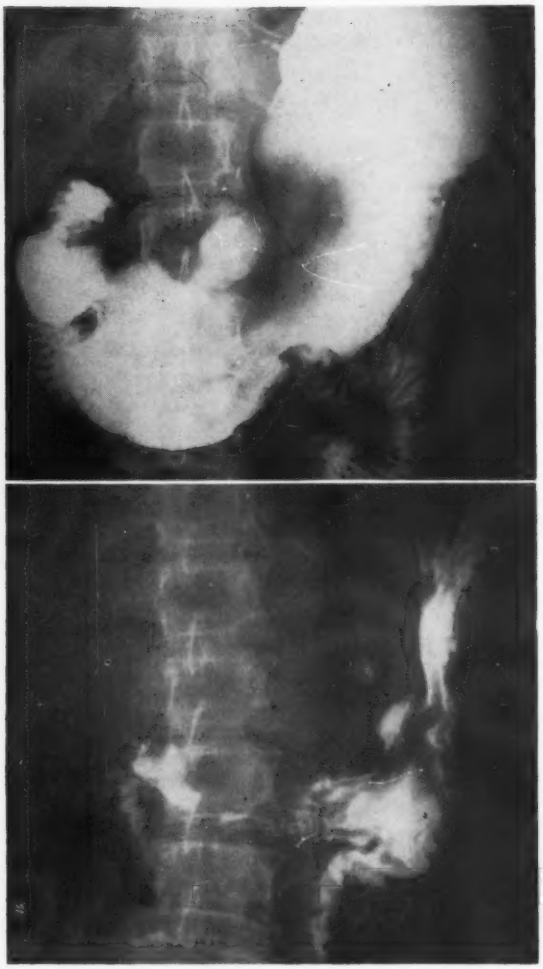

Fig. 8. Roentgenologically diagnosed and confirmed as benign, this large gastric ulcer in a male aged sixty presents a radiolucent "collar" common in large benign ulcers but also found in malignancy.

degrees of deformity secondary to chronic benign ulceration than is true in the remainder of the stomach. Figure 10 illustrates a lesser curvature prepyloric ulcer which was associated with complete loss of the mucosal pattern and an annular narrowing suggestive of a tumor mass. These findings naturally led to suspicion of carcinoma. Subsequent histologic examination proved the lesion to be benign. The degree of deformity resulting from benign ulcers in this area must undoubtedly explain a part of our error in this group. Significantly, those lesions which had all the roentgen characteristics of benignity did

Table III

PREPYLORIC GASTRIC ULCERS
Within 2.5 cm. of pylorus

	Roentgen Diagnosis	Histologic Diagnosis	
	No. of Cases	Benign Cases	Malignant Cases
Benign	20	19	1
Probably benign	3	3	0
Probably malignant	4	3	1
Malignant	10	4	6
Total	37	29	8

prove to be benign histologically (Fig. 11). As a result, there was no decrease in diagnostic accuracy when the ulcer was benign roentgenologically. Likewise, the typically malignant prepyloric ulcer can hardly be

Fig. 9. A "giant" malignant gastric ulcer in a fifty-nine year old female patient shows the crater within a larger tumor mass which does not project beyond the gastric margin. The roentgenologic diagnosis of malignancy was confirmed in this case.

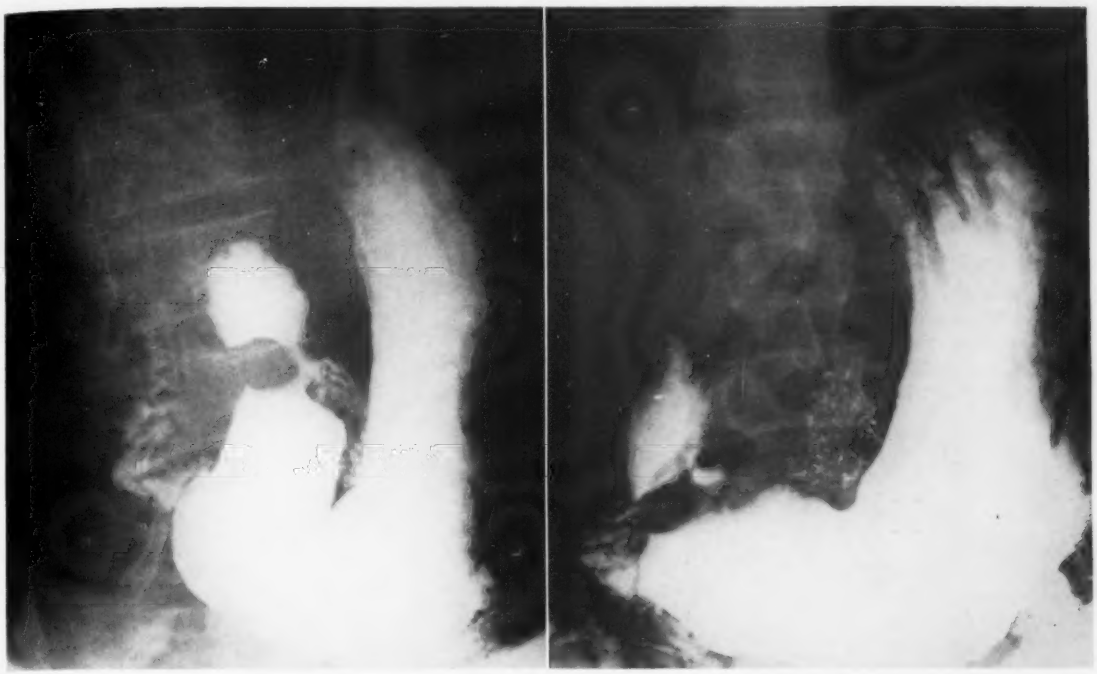

Fig. 10. In a fifty-two year old male, this benign prepyloric ulcer shows loss of mucosal pattern and annular narrowing suggestive of tumor mass and malignancy. Roentgenologically misdiagnosed as malignant.

mistaken (Fig. 12). The crater is irregular and the surrounding mucosal folds are completely obliterated. An associated palpable mass in this instance added further convincing evidence.

UNSELECTED ULCERS

The remainder of the ulcerating lesions in this study (Table IV) consisted of the 101 cases which did not fall into any of the categories previously described. These cases, therefore, demonstrated ulcers less than 2.5 cm. in diameter, all of which were on the lesser curvature of the antrum and body of the stomach. In this group, an incorrect roentgenologic diagnosis of malignant or probably malignant disease was made in 10 cases and an incorrect diagnosis of benignity in 2. The total error thus calculated is 12 of 101, or 12 per cent. Among the 52 cases diagnosed as benign only 2 errors occurred, an inaccuracy of 4 per cent. This error is no greater than that claimed by surgeons who rely upon gross examination of the stomach; their error is estimated to be between 14 and 18 per cent. An incorrect roentgenologic diagnosis of malignancy was less frequent in this group than in the selected cases (20 per cent as compared to 37 per cent). This probably reflects the influence of former

Table IV

SUMMARY OF ALL CASES OF CONFIRMED GASTRIC ULCERATION EXCLUDING GREATER CURVATURE, GIANT AND PREPYLORIC ULCERS

	Roentgen Diagnosis	Histologic Diagnosis	
	No. of Cases	Benign Cases	Malignant Cases
Benign	51	49	2
Probably benign	1	1	0
Probably malignant	4	4	0
Malignant	45	6	39
Total	101	60	41

Total error: 12 out of 101 or 12 per cent.
Benign roentgenologic diagnosis incorrect: 2 out of 52 or 4 per cent.

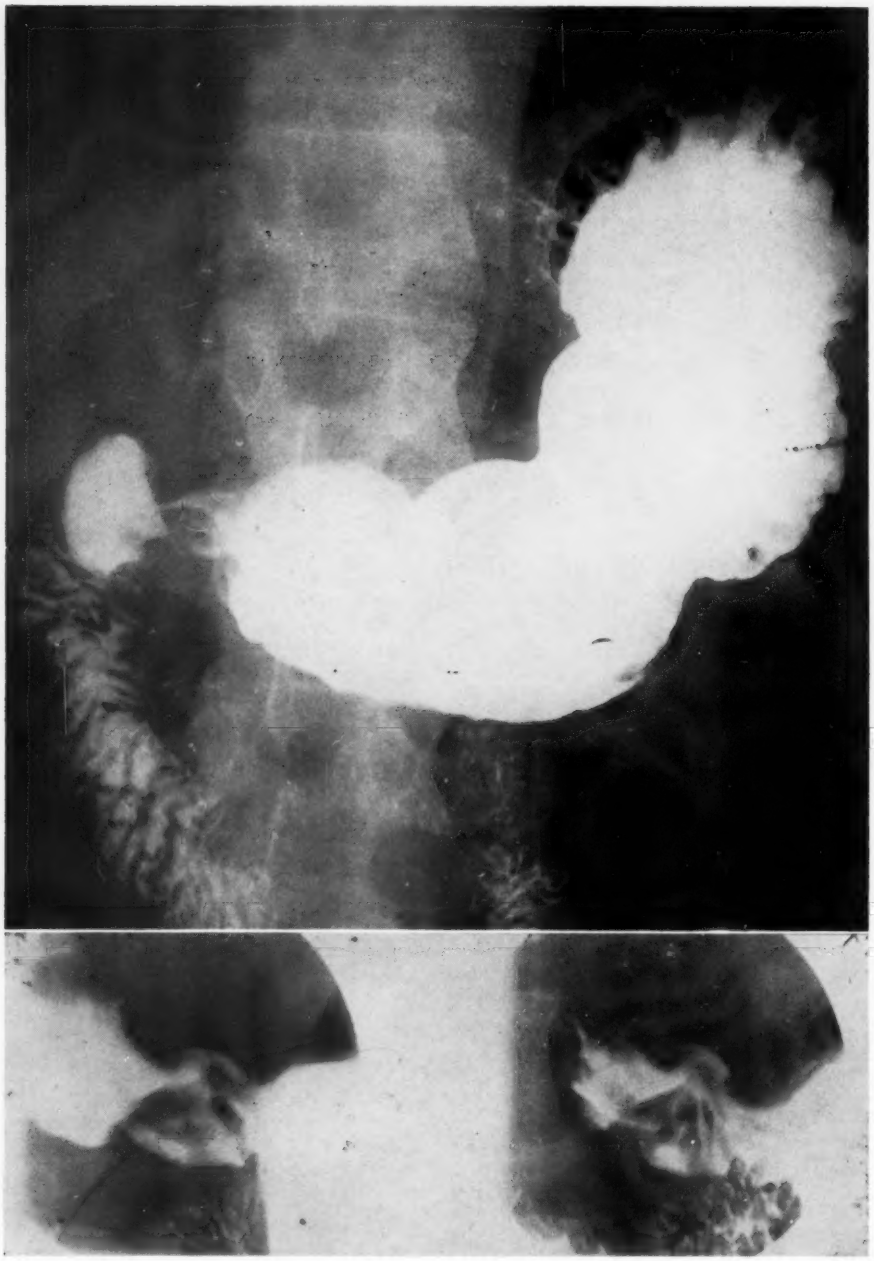

Fig. 11. A gastric ulcer demonstrating radiating mucosal folds, overhanging edges and a smooth crater extending beyond the gastric margin. This was discovered in a sixty-four year old male and called benign both roentgenologically and histologically.

beliefs regarding significance of size and location of ulcerating lesions.

DISCUSSION

From examination of previously presented data and from the many recent reports of other authors, it should be apparent that there is no statistical evidence lending credence to the dogma of "malignant until proved otherwise" when an ulcer is either large in size or located in the prepyloric area or on the greater curvature of the stomach. Instead, it would appear that there is at least an even statistical

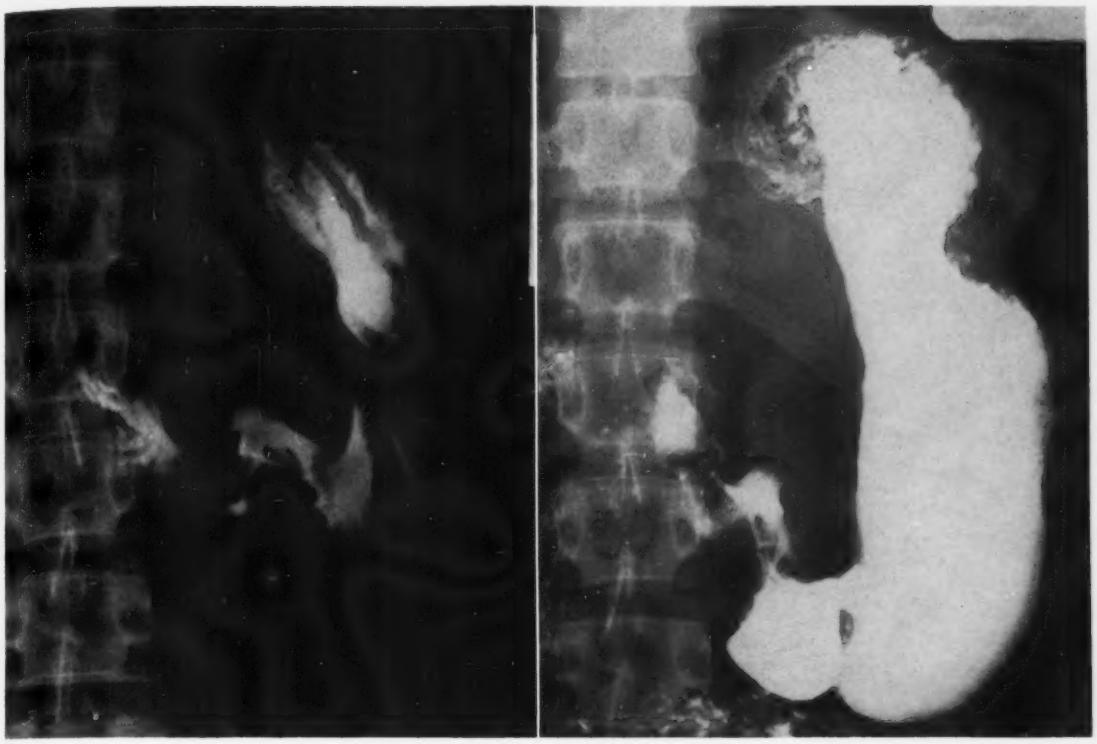

Fig. 12. A typically malignant prepyloric ulcer with an irregular crater and obliterated mucosal folds was diagnosed in a thirty-nine year old female and histologically confirmed.

chance that these lesions will be benign. If such is true, it becomes important to evaluate our percentage error in the roentgenologic differentiation of benign and malignant ulcers appearing in these categories.

Table v summarizes all of the cases included in the three selected groups previously discussed. Duplications have been eliminated from this final summary and each case is counted only once. A total of 90 cases, all histologically verified, are presented. An incorrect roentgenologic diagnosis of "malignant" or "probably malignant" disease was made in 15 cases and an incorrect diagnosis of benignity in 3. The total error is thus calculated as 18 out of 90, or 20 per cent, a rather high figure. Most significant, however, are the 3 errors encountered in the 49 cases roentgenologically diagnosed as "benign" or "probably benign," an error of only 6 per cent. This figure compares favorably with that in the unselected cases. Thus, there appears to be an increase in error in the roentgenologic diagnosis of benign ulcers in these selected

Table V

SUMMARY OF ALL REPORTED CASES IN THREE CATEGORIES INCLUDING GREATER CURVATURE, GIANT, AND PREPYLORIC ULCERS

(duplications excluded)

	Roentgen Diagnosis	Histologic Diagnosis	
	No. of Cases	Benign Cases	Malignant Cases
Benign	42	39	3
Probably benign	7	7	0
Probably malignant	7	4	3
Malignant	34	11	23
Total	90	61	29

Total error: 18 out of 90 or 20 per cent.

Benign roentgenologic diagnosis incorrect: 3 out of 49 or 6 per cent.

groups as compared to the unselected group.

Each lesion should be judged on its own merits, applying all of the well established roentgenologic criteria for recognition of the benign gastric ulcer. These are as follows: (1) projection of the ulcer crater beyond the apparent gastric margin, (2) absence of an irregular filling defect or infiltration about the crater, (3) radiation of mucosal folds toward the ulcer, (4) presence of overhanging edges and (5) regularity of the ulcer niche.

Obviously, one cannot depend upon single anteroposterior projections of the barium filled stomach in establishing the presence or absence of these signs. Multiple positions, films of the mucosal pattern and detailed "spot" roentgenograms of all suspected areas should be utilized. Finally, when in doubt, err on the side of malignancy.

SUMMARY

A study of gastric ulcers discovered by roentgenologic examination performed at the Mallinckrodt Institute of Radiology between the years 1947 and 1955 is presented. Reference is made to remarks of earlier investigators concerning the diagnostic significance of size and position of gastric ulcers. The accuracy of roentgenologic diagnosis of 90 ulcerating lesions of the stomach which were characterized by giant size, prepyloric or greater curvature location was compared with accuracy of diagnosis of 101 unselected cases. No significant difference was found. It was concluded, therefore, that the size or location of an ulcer was of no diagnostic significance.

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MULTIPLE CHRONIC GASTRIC ULCERS

REPORT OF A CASE WITH FOUR SIMULTANEOUS ULCERS*

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INSTANCES of simultaneous, multiple, chronic ulcerations of the stomach constitute only a small percentage of the large numbers of recorded cases of chronic peptic ulcer. There is no explanation as to why the disease is usually manifested by only a single ulcer, nor is the significance of simultaneous, multiple ulcerations known. The problem of multiple gastric ulcers has been studied from postmortem and postoperative specimens in the past, and while as many as 32 acute, superficial ulcers have been found in one stomach,[9] the greatest number of ulcers detected roentgenologically has been three.

The roentgenologic finding of four large chronic gastric ulcers, present simultaneously in a patient, is a rarity which has not been recorded previously, and is the subject of this report.

REPORT OF A CASE

Present Illness. In February, 1954, a sixty year old white male was admitted to the Brooklyn Veterans Administration Hospital with a chief complaint of right lower quadrant abdominal pain of two and one-half weeks' duration. There was no associated nausea, vomiting or diarrhea, and there had been no dysuria, frequency or other urinary complaints. The patient gave no history of anorexia, melena or hematemesis.

Past History. Early in 1948, the patient was admitted to the Manhattan Beach Veterans Administration Hospital because of left upper quadrant pain. Studies at that time included negative gastrointestinal and barium enema examinations. He was discharged without a definitive diagnosis after a spontaneous remission of his symptoms. However, several months later, in 1948, he was re-admitted to the same hospital because of recurrence of diffuse abdominal pain. Owing to the severity and persistence of the pain, an exploratory laparotomy was performed some twenty-four hours after admission. At this time a perforated prepyloric gastric ulcer was found. This was repaired and after a stormy postoperative course the patient recovered.

Physical Findings and Hospital Course. The physical examination at the time of admission revealed a fairly well developed but somewhat poorly nourished male in no acute distress. In the right lower quadrant of the abdomen, which was soft and relaxed, there was an oblong mass, measuring approximately 6 by 3 cm. The mass which was tender to touch extended deep into the abdomen. There was also a large left inguinal hernia. The white blood cell count on admission was 12,400 per cu. mm. with 88 per cent polymorphonuclear cells and a hemoglobin of 8.6 gm. per cent. The chest roentgenogram revealed pulmonary emphysema and a plain film of the abdomen showed a grapefruit-sized mass which appeared to encroach on the region of the cecum. The barium enema study suggested an intussusception of the cecum into the ascending colon. After the hemoglobin was raised to appropriate levels by blood transfusion, the patient was operated on in March, 1954. A large mass in the appendiceal region was found, and a right hemicolectomy and ileotransverse colostomy were done. Histopathologic study of the specimen revealed an appendiceal abscess with foreign-body, giant-cell granuloma.

The postoperative course was uneventful and the patient was given a thirty day leave of absence to recuperate. In April, the patient returned stating that he had been having persistently tarry stools since leaving the hospital. The hemoglobin was 7.4 gm. per cent. A gastrointestinal roentgenologic study showed four gastric ulcerations. The highest one was located on the posterior wall towards the lesser curvature. The second ulcer was on the lesser curvature and measured approximately 1 cm. in diameter. The third ulcer measured about 3 cm.

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and was also located on the lesser curvature. The fourth ulcer was located in the region of the pylorus and measured approximately 1 cm. in diameter (Fig. 1, *A* and *B*).

A subtotal gastrectomy with anterior gastrojejunostomy was performed.

Gross examination of the stomach specimen revealed four separate gastric ulcers, described as follows: There was a large ulcer crater on the less curvature in the central portion of the specimen which measured 3.5 cm. in its greatest diameter. The crater extended to both the anterior and posterior walls. The second ulcer was on the lesser curvature, proximal to the large one described above. This measured 1.5 cm. in diameter and consisted of moderately firm tissue with thickening and puckering of the serosa. Distal to the first described ulcer, there was a third area of ulceration on the lesser curvature just at the pyloric ring. This ulcer measured 0.6 cm. in its greatest diameter. The edges were sharp and not undermined. A fourth ulcer was present on the posterior wall adjacent to the lesser curvature and was situated approximately midway between ulcers one and two. This measured 1.2 cm. in its greatest diameter (Fig. 2). Microscopic examination of the four ulcerated areas disclosed chronic gastric ulceration with benign features.

The patient did well postoperatively and was discharged from the hospital on May 19, 1954. He was last seen in September, 1955, at which time he was asymptomatic.

DISCUSSION

The problem of multiple gastric ulcers has interested investigators for some time. Judd and Proctor[6] reported on a study of 1,475 cases of gastric ulcer in 1925. They found two or more ulcers present in 87 cases, a 6 per cent incidence. Of the 87

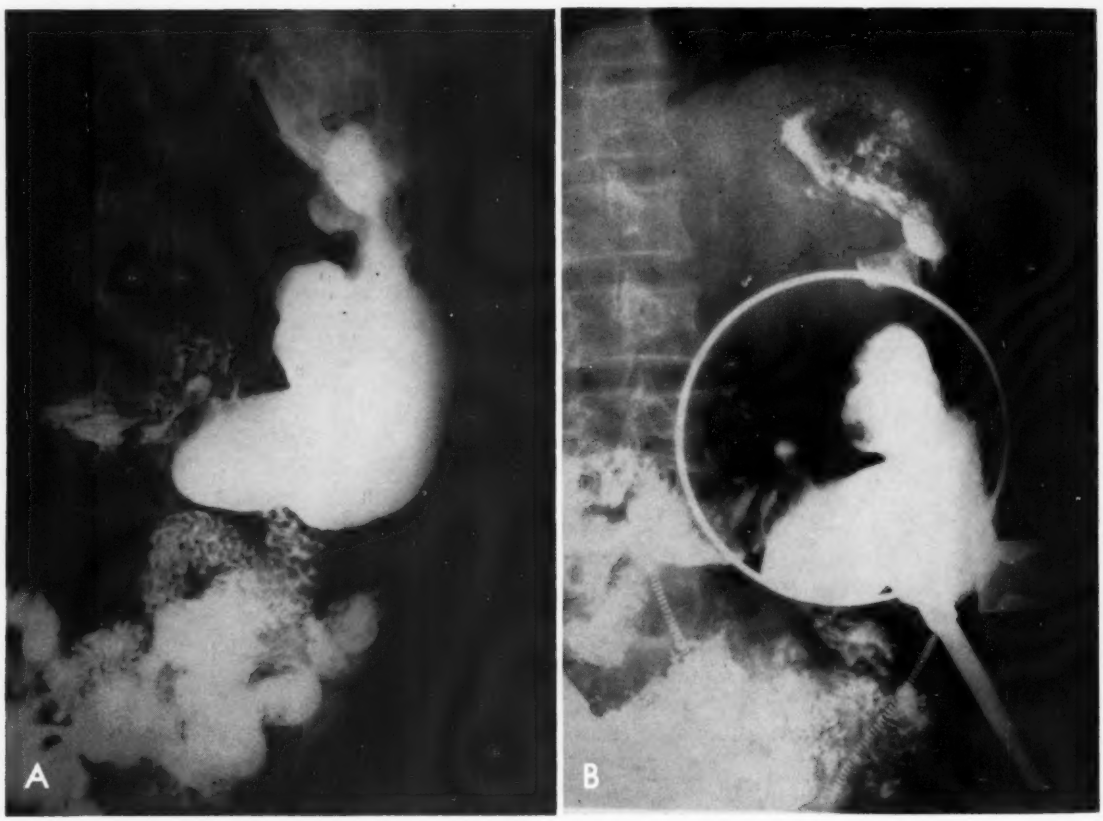

Fig. 1. (*A* and *B*) Roentgenograms of barium filled stomach and with compression study. The highest ulcer is seen *en face*, lying towards the lesser curvature. On the lesser curvature are seen three additional ulcers: one at a slightly lower level than the *en face* ulcer, the second and largest at the angulus and the third at the pylorus.

Fig. 2. Operative specimen of resected stomach showing four ulcers. In the central portion of the specimen (black arrow) there is a large defect representing the base of the largest ulcer which had been left *in situ*. This crater measured 3.5 cm. and extended to both the anterior and posterior walls of the stomach. Upper white arrow indicates ulcer on the lesser curvature measuring 1.5 cm. Lower white arrow indicates ulcer at the pylorus. The fourth ulcer, measuring 1.2 cm., is on the posterior wall, adjacent to the lesser curvature (indicated by black arrow at lower right).

cases, 63 per cent had two ulcers, 20 per cent had three ulcers, and 17 per cent had more than three ulcers. The largest number of ulcers in a single case was 22. Roentgenologically, however, there was evidence of two ulcers in the stomach in only 2 of these cases. Two additional cases were reported as showing one ulcer and probably a second one.

A patient in whom roentgen study disclosed three ulcers on the lesser curvature of the stomach was reported by Bockus.[1]

In a study of 1,552 consecutive surgical specimens at the Mayo Clinic,[3] there were 19 patients with at least two chronic, benign gastric ulcers. Six patients in this group were reported as showing three or more active chronic ulcers. There was no mention, however, of preoperative roentgen demonstration of these ulcers.

Russell, Weintraub, and Temple,[8] in a review of 405 cases of gastric ulcer, found multiple ulceration in 23 cases (5.7 per cent). Three ulcers were seen only once in this series and were demonstrated roentgenologically. Only 10 of the remaining 22 double ulcerations were demonstrated by roentgen examination.

In a review of 138 cases of gastric ulcer Gott, Shapiro, and Kelty[4] found 10 instances of multiple gastric ulceration. Nine of this group had two ulcers and one had three. There was no mention of the preoperative roentgen findings in these cases.

A study of 1,000 cases of gastric ulcer at the Lahey Clinic[10] revealed 912 cases of benign gastric ulcer. In this group there was roentgenologic demonstration of 21 instances of multiple ulceration but no specific mention was made of the exact number of ulcerations present. Only one of 84 malignant gastric lesions showed more than one ulcer.

Welch and Allen[12] reviewed 512 cases of gastric ulcer at the Massachusetts General Hospital and found multiple ulcers present in 8 per cent. One patient showed roentgenologic evidence of four gastric ulcers, but this was not substantiated in the surgical specimen which showed only two ulcerations.[13] These authors concluded that gastric ulcer was usually benign when multiple and only occasionally associated with cancer.

Reviewing 9,171 consecutive necropsies at the Cook County Hospital from 1929 to 1936, Portis and Jaffe[7] found 457 cases of all types of peptic ulcerations. Peptic ulcer, both duodenal and gastric, was present in 118 cases. Of this group, 55 cases showed gastric ulceration but only 3 were instances of multiple ulceration.

In a report from the Cleveland Clinic,[2] 2 cases of multiple benign ulceration of the greater curvature of the stomach were described. The first case showed two ulcerations and the second four. However, the roentgenologic studies in both cases failed to demonstrate multiplicity of ulceration.

Johnson and Hawthorne[5] have reported 2 cases, each with three benign gastric

ulcers which were visible roentgenologically. In one of these cases all three ulcerations were present on the greater curvature of the stomach.

Silk, Blomquist, and Schindler[9] reported 18 cases of ulceration of the greater curvature of the stomach, 8 of which proved to be benign. In some of these patients benign ulcer of the greater curvature was associated with an ulcer of the duodenum or with a benign ulcer of the lesser curvature of the stomach. Thus, a finding of multiple ulceration in which one of the ulcers is on the greater curvature suggests that the latter also is probably benign.

SUMMARY

Studies of large series of surgical and postmortem specimens indicate that multiple ulceration of the stomach occurs in about 2 to 12 per cent of cases.

A case of four distinct chronic gastric ulcerations, roentgenologically demonstrated, is presented.

To our knowledge, this represents the first reported instance in which the diagnosis of four gastric ulcerations was made roentgenologically and subsequently confirmed at operation.

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ACUTE VOLVULUS OF THE STOMACH EMPHASIZING MANAGEMENT HAZARDS

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THE general connotation of the term volvulus is that of "an obstruction due to twisting or knotting of the bowel." The earliest reports of volvulus of the stomach were based upon postmortem findings and the obstructive aspect was repeatedly emphasized. More recently, the term volvulus has been applied to the mere finding of a distorted position of the stomach or torsion of some degree even though *obstruction* were not present.

As early as 1866, Berti[4] reported an obstruction of the stomach with interlacing of the esophagus and duodenum, stating that: "When the entire mass of organs, including the spleen and the pancreas, had been made to make two complete turns, horizontally from left to right, each viscus was restored to normal position and the channel once more became patent."

The rarity of this sort of complication can be appreciated when realizing that regardless of the zeal of postmortem investigations during those years, apparently the second such case was not reported until eight years later, in 1874, by Mazzotti.[14] There followed similar reports by Dini,[8] in 1879, Langerhans,[12] in 1888 and Saake,[17] in 1893.

Berg[3] is credited with first handling volvulus of the stomach by surgery, in 1897; Rosselet[16] is credited with first identifying this condition roentgenologically, in 1920.

Thereafter, reports became more numerous, though Buchanan,[7] in 1930 was able to find a record of no more than 30 such cases up to that time. Lazzarini[13] collected only 90 cases from the literature up to 1940; Bazzano and Hood[2] found 76 cases reported between 1930 and 1952.

Roentgenologic studies seem to have influenced description of "volvulus" where the essential finding was merely torsion. For instance, Hamilton[10] reported 11 cases, Singleton,[19] 3 cases, and Gottlieb, Lefferts and Beranbaum,[9] 20 cases—each of these writers describing volvulus of the stomach even though barium was admitted into the stomach and even though it passed on into the duodenum. Thus, these more numerous reports have featured the torsion or twist, minimizing the matter of obstruction.

Perhaps we should consider these latter cases as *partial* volvulus, although this term has been used to describe cases where obstruction was found to have been produced by torsion of only a *portion* of the stomach.[7,18]

It has been emphasized that torsion may occur up to 180 degrees without obstruction or strangulation of blood supply. With a twisting beyond 180 degrees, there usually results a complete obstruction with clinical manifestations of an acute abdomen. This type of case presents the Borchardt and Lenormant triad,[9,20] *i.e.*, (1) vigorous efforts to vomit without result, (2) circumscribed epigastric pain, and (3) impossibility of passing a stomach tube—or as Toygar[20] stresses it: "obstruction to the flow of barium from the esophagus into the stomach." An example of such a case is presented.

REPORT OF A CASE

Mrs. S. L., aged seventy-five, after a large dinner at noon, was seized with cramping epigastric pain about 3:00 P.M. on the day of hospital admission. She retched but was unable to vomit. She took baking soda, which was her custom when she had a gastric upset, but obtained no relief. About 7:00 P.M., she summoned her physician. She was found writhing with pain of an unrelenting character which she described as a "bursting pain," with aching radiation into her back.

When questioned, she remarked of having had two previous episodes of this sort during

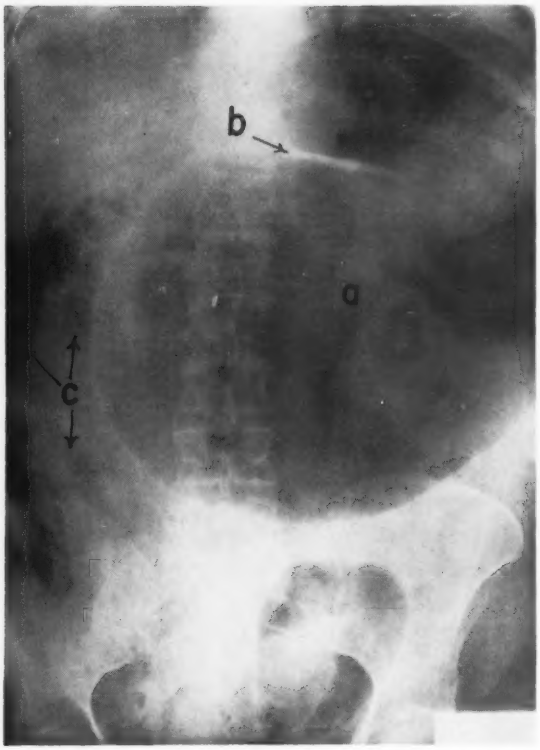

FIG. 1. Preliminary roentgenogram of the abdomen; patient supine. Observe: (a) markedly distended viscus; (b) incisura directed toward right upper quadrant; (c) distention of coils of small intestine and colon—lack of continuity of the gas column in these segments, the evidence being of an associated adynamic ileus.

the year. On one occasion she was examined in Seattle, where a gastrointestinal study was performed, and she was told that she had a condition of the stomach that should not be "reduced" because of her age. On another occasion when the pain was of comparable severity, she was given morphine. The morphine had very little immediate effect, and the doctor left a syringe so that the injection might be repeated by her daughter during the night, if necessary. However, the following morning, she was entirely well.

General examination revealed an individual of mental alertness, and apparently nontoxic, rolling restlessly in bed. A large mass, which was more conspicuous on the left side, distended the upper abdomen. The mass was tympanitic, and there was extreme tenderness when digital pressure was applied anywhere over the abdomen. The heart sounds were normal and her blood pressure was 176 systolic, 106 diastolic.

Unsuccessful attempts were made to pass a stomach tube. A smaller tube was obtained and again passage into the stomach was impossible. An obstruction "was encountered at a distance of 18 to 20 cm." She was then given about a quarter of a glass of liquid which she immediately vomited.

Her pain was so severe that 50 mg. of demerol was given intramuscularly. This failed to provide any significant palliation and the same dose of demerol was repeated at intervals of one-half hour until a total of 300 milligrams had been injected—with no relief. Finally, at 8:15 P.M., she was given one-sixth grain of morphine sulphate intramuscularly and brought to the hospital.

Roentgenoscopy and roentgenography were accomplished immediately, with findings as shown in Figures 1 and 2. Thin barium was then given with the patient in the semi-upright position, but the barium did not enter the stomach. Rotation studies indicated a hiatal herniation distal to the conical tapering of the column of barium in the esophagus (Fig. 3). Under direct visual control, cautious attempts were again made without success to pass a soft rubber tube into the stomach.

The problem was considered a surgical emergency and the patient was then transferred to a wheeled gurney. While waiting for the elevator to take her to surgery, she was rotated onto her right side. This caused her to vomit at least 3,000 cc. of food and fluid. Almost immediately, she remarked that she felt "so good;" then collapsed and died.

Roentgenography was accomplished immediately postmortem to determine whether she might have drowned in her own vomitus (though precautions to counteract such had been taken). The lungs showed good aeration; however, a massive distention of the stomach was still present (Figures 4, *A* and 4, *B*).

Antemortem laboratory findings: Hemoglobin, 12.7 grams; red blood cell count, 4,200,000; white blood cell count, 7,400, of which 79 per cent were polymorphonuclears (8 per cent of these being segmented forms), 20 per cent lymphocytes and 1 per cent monocytes.

Pertinent findings at postmortem examination:* "Upon opening the abdomen, no free

* Courtesy quotation of autopsy report by J. L. Zundell, M.D., Pathologist, Saint Francis Memorial Hospital, San Francisco, California.

Fig. 2. Lateral projection; patient supine. Again, observe: (a) markedly distended viscus; note extension toward the diaphragm and a constricted column apparently extending through the diaphragm (arrow), communicating with (e) hiatal sacculation. Further, observe (c) distention of loops of small intestine with typical hairpin turns upward. As to be expected, a fluid level is visualized in the dependent portion of the volume distention of the viscus (a).

fluid was present. The stomach was markedly dilated and numerous loops of bowel showed dilatation. Several segments of bowel, which had a dark reddish black color and appeared to contain blood, were scattered throughout the abdomen and limited to the small intestine. There was an increased amount of fat in the mesentery and omentum which was free. The epiploic foramen was open and the duodenal folds were present. The appendix was present and retrocecal. There was a large hiatal herniation present which will be described in detail later. The diaphragm arched to the fourth interspace on the right and the fifth interspace on the left. The liver was above the costal margin, both at the xiphoid and in the right anterior

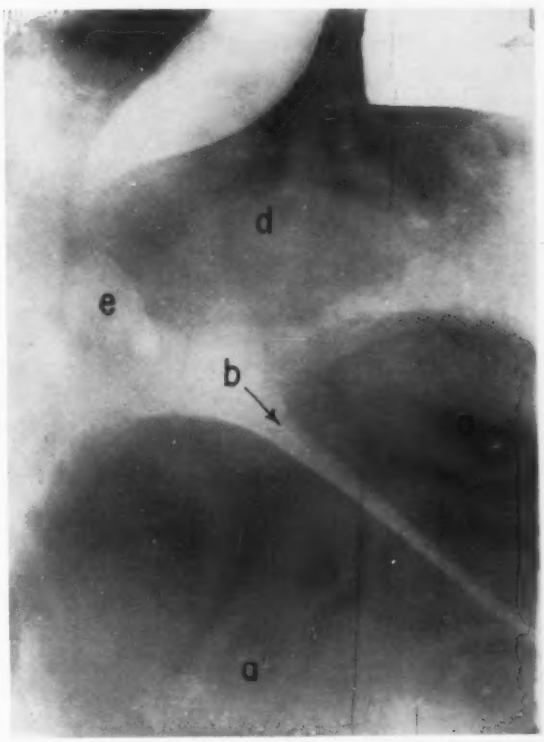

Fig. 3. Swallowing function study; patient supine and in right anterior oblique position. Observe: (a) markedly distended viscus; (b) prominent incisura, directed to the right upper quadrant; (d) hiatal sacculation; (e) barium bolus showing spiral tapering at the site of obstruction—the esophagogastric junction.

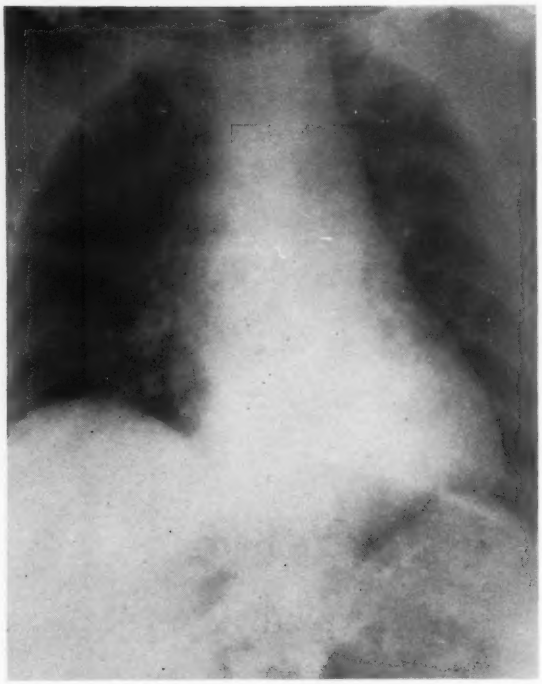

Fig. 4. (*A*) Postmortem roentgenogram of the chest. No evidence of fluid aspiration in the lung fields.

axillary line. There was interstitial hemorrhage in the posterior parietal tissues just beneath the spleen. This amounted to approximately 5 cc. of blood. It was present in the retroperitoneal fat. No other areas of free hemorrhage were present. The hiatal hernia was located at the left of the esophagus and admitted three fingers, and the small portion of the cardiac end of the stomach was incarcerated within the hernial sac. It was pulled out readily, however, and there were no adhesions. The remainder of the stomach was markedly dilated and on relieving the herniated portion, gas ballooned the stomach out to a point that it measured 17.0 cm. from lesser to greater curvature. The abdominal organs were in their normal anatomic sites except for the extreme distention of the stomach. It appeared to cause twisting of the first portion of the duodenum with a fold across its first portion. The omentum was free and there was no evidence of mesenteric thrombosis. The esophagus was markedly dilated and there appeared to be superficial ulceration of the cardiac end covered by a grayish necrotic pellicle. The lower end of the esophagus and approximately one-fourth of the stomach from the cardiac end was incarcerated within the hiatal hernia previously mentioned. The hernia was approximately 9.0 cm. long and 6.0 cm. in diameter at the mouth. The portion of the stomach which was incarcerated within the hernia showed congestion and appeared dark greenish gray in color. One large, irregular, pressure ulcer was apparent which measured 4.0 cm. in diameter. The remainder of the stomach was markedly thin and of a greenish gray color. The stomach was estimated to contain approximately 1 liter of partially digested food, mucus and fluid, and a large amount of air. In the stomach there appeared to be a plication of the mesentery across the first portion of the duodenum, which may have been responsible for the valve-like action and was probably the site of the volvulus. This is difficult to prove, however, since depressing the stomach relieved the plication. No intrinsic lesion was found in the duodenum or in the remainder of the gastrointestinal tract, but there was bloody fluid present within the in-

Fig. 4. (*B*) Postmortem roentgenogram of the abdomen. Residual distention of stomach, despite the considerable vomiting. Undoubtedly this residual distention indicates gastric atony since there was evidence of patency at the esophagogastric junction as disclosed by the regurgitations. Again, it will be noted that there was a gaseous distention of loops of small intestine and colon; the latter indicating an associated adynamic ileus.

testine at several points, and there was marked congestion of the mesenteric vessels.

DISCUSSION

Various factors have been thought to cause torsion of the stomach such as to result in volvulus[1,2,9,15,18] Among these are undue stretching of the gastrohepatic or the gastrocolic ligaments, overdistention of the stomach or the transverse colon, traction by an exceptionally mobile spleen, gastric or extragastric tumefaction (even including pregnancy), phrenicotomy, eventration or herniation of the diaphragm, ulceration in the stomach or duodenum, etc.

Hiatal herniation was a complication in our patient. She remarked of a "condition of the stomach that should not be reduced because of her age." Our studies indicated that her stomach consisted of two compartments—the hiatal sacculation above the diaphragm and the main portion below the diaphragm. It might be theorized that the initial twist occurred at the esophagogastric junction because of overdistention of the hiatal sacculation; that in the beginning, a one-way valve resulted at the junction between the main portion of the esophagus and this sacculation; and that, after the baking soda was ingested the effervescence distended the sac so greatly as to close off the return. Regurgitation or vomiting were ineffectual. The gas and fluid moved on into the subphrenic portion of the stomach, progressively distending the latter until with overdistention, a twisting occurred at the first portion of the duodenum. Seemingly, the latter twist was the more complete, for eventually there was some release of the obstruction at the esophagogastric junction though apparently not at the duodenum.

The pain became intense. It was not relieved by ordinary doses of demerol. Even with 300 milligrams over a period of approximately six hours, plus one-sixth grain of morphine sulphate, the patient remained conscious but writhing in pain. However, with release of the pain stimulus she collapsed and died. Her death might be attributed to respiratory failure (because of relative oversedation—*i.e.*, after withdrawal of the pain stimulus), and visceral collapse, as indicated by the engorgement of the mesenteric vessels. Certainly, both of these factors must be anticipated in managing reduction of an excessively distended viscus.

This case also demonstrated the hazard of attempting to provide relief by exerting even minimal pressure in passing a stomach tube. Three such attempts were made, all with caution. Nevertheless, the pathologist noted ulceration in the distal esophagus.

DIFFERENTIAL CONSIDERATIONS

Gastric Atony. This condition of course occurs to some extent with volvulus but may be found independent of it, particularly in older individuals. It should not be difficult to differentiate gastric atony from volvulus of the stomach since with atony, barium will pass readily from the esophagus into the stomach. After rotating the patient to the right lateral decubitus position, some barium should flow into the duodenum. With this latter position, muscular tone may partially be regained by having the patient concentrate on food which he particularly relishes.

Intestinal Obstruction. Though volvulus of the stomach is a type of obstruction, when the obstruction pertains to segments of the alimentary tract distal to the stomach, the clinician is likely to consider bulk distention attributable to the stomach itself. Roentgenoscopic and roentgenographic studies should be made with the patient in the supine position as well as in the upright and left lateral decubitus positions. In the case of volvulus of the stomach, there will be no shift in the position of the markedly distended "hairpin loop" as compared to the shift of loops with obstruction in the small intestine or colon. In the supine position coils of distended small intestine ordinarily arrange themselves in a stepladder pattern. When the patient is in the decubitus position, they will be arranged as hairpin turns directed

upward, whereas distended segments of the colon will be arranged longitudinally. In the upright or decubitus positions, multiple fluid levels can be expected with volvulus either of the small intestine or of the colon. Insofar as obstruction of the colon is concerned, more definite proof might be obtained by a barium enema study whereby the level of obstruction can then be located.

Sigmoid Volvulus. The distended hairpin loop usually extends from the left lower quadrant with the hairpin incisura being directed toward the left lower quadrant. The upright position as compared to the left lateral decubitus position produces no significant change in position of the distended loop—just as with volvulus of the stomach.

Cecal Volvulus. The distended loop ordinarily extends from the right lower quadrant to the left upper quadrant with the hairpin incisura, if present, being directed to the right lower quadrant. Here again, studies in both, the upright and the decubitus positions ordinarily show no significant change in the position of the distended loop.

Where either a sigmoid volvulus or a cecal volvulus is strongly suggested, a barium enema study should be convincing with evidence of stoppage of influx at the site of the torsion.

Acute Pancreatitis. Plain films of the abdomen with the patient supine should reveal segmental dilatation of loops of the jejunum and also of the transverse colon with relative lack of continuity of the gas column which is evidence of a selective type of *adynamic* ileus. The degree of distention of the transverse colon, however, may be so marked as to be confused with gastric distention. Distention of the stomach may be excluded by administering a slight amount of barium and observing its passage through the esophagogastric junction and by proper positioning, even through the pylorus. A more complete upper gastrointestinal study might reveal segmentation in the duodenum and jejunum; possibly, some evidence of pressure by the common bile duct, particularly as the patient is rotated to the right lateral decubitus position, or evidence of pressure by the head of the pancreas upon the second and third portions of the duodenum. In the true lateral projection, there may be a slight anterior deviation of the fundus of the stomach (particularly if the patient is in the upright position and resting on the right side), or a prominence due to soft tissue tumefaction in the region of the pancreas.

Ruptured Peptic Ulcer. A scout roentgenogram of the abdomen such as described above should distinguish free gas in the peritoneal cavity with leveling of such when the patient is examined in the upright position as compared to the left lateral decubitus position.

SUMMARY

The subject of volvulus of the stomach is presented with a report of a case:

1. Acute volvulus of the stomach is a condition rarely encountered. It may account for an acute abdomen. It is a surgical emergency.

2. The term should be limited for connotation of *obstruction* due to torsion. Unless there is a definite degree of obstruction, it would seem improper to use the term volvulus.

3. The typical clinical features are: (a) ingestion of a large meal followed by hiccoughing, severe distention of the abdomen, retching and inability to vomit, (b) development of a constricting type of epigastric pain; and (c) aching in the back.

4. The roentgenologic criteria are: (a) localized massive distention of the upper abdomen; (b) frequently, visualization of outlines of a "hairpin loop" with incisura directed toward the right upper quadrant or posteriorly; (c) fixation of the loop regardless of decubitus or Trendelenburg positioning of the patient, delimitation of ingested barium at tapered extremity of the esophagus; (d) possible evidence of a hiatal sacculation or other diaphragmatic

herniation; (e) perhaps, evidence of deviation in position of the spleen—anteriorly or inferiorly; and (f) likely, segmental distention of loops of small intestine and of the colon which is evidence of an associated adynamic ileus.

5. Warnings as to management of acute volvulus are: (a) hazard pertaining to prevalent procedure of taking baking soda for relief of "gastric distress"; (b) importance of counteracting oversedation before relieving tension of a distended viscus; (c) hazard associated with attempts to pass a stomach tube; and (d) prompt surgical relief with assistance as to pharmacologic and fluid balance requirements, if possible by the services of a medical anesthetist.

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MEGADUODENUM IN THE ADULT

REPORT OF A CASE

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MEGADUODENUM in the adult is rare. The following case illustrates the clinical and roentgenologic findings, as well as a new surgical approach to the management of this entity.

REPORT OF A CASE

The patient, J. E. B., a white male sixty-one years of age, entered Scripps Memorial Hospital in June, 1950, complaining of a sense of fullness in the epigastrium and a weight loss of about twenty pounds during the previous six months. He was known to be a mild diabetic.

There was a past history of attacks of "indigestion" at intervals since the age of twenty-five. At times these attacks occurred daily, at other times a week or more would elapse between them. They were most common about one hour after a meal, and consisted primarily of bloating and epigastric distress. The attacks were more common after fatty or spicy foods, and were partially relieved by antacids. There was no history of nausea or vomiting, nor was there any evidence of bleeding from the gastrointestinal tract.

On physical examination it was noted that there was ballotable fluid within the abdomen which produced audible gurgling. There were no other physical findings of significance.

Other than for a moderate elevation of the blood sugar, the laboratory findings were not unusual.

Roentgenologic examination of the upper gastrointestinal tract revealed a marked dilatation of the duodenum and a moderate dilatation of the stomach (Fig. 1). There was nothing to suggest abnormality of the portion of the small intestine beyond the duodenum. It was thought that there was a partial obstruction in the region of the ligament of Treitz.

The patient was prepared for surgery for four days by means of suction with a Miller-Abbott tube. During this time he was given a liquid diet. At the end of three days the tip of the Miller-Abbott tube progressed thirty-two inches beyond the pylorus of the stomach.

A laparotomy was performed under spinal anesthesia, using a right pararectus incision. Exploration of the peritoneal cavity revealed thin-walled dilatation of most of the duodenum. The upper half of the ascending portion was not dilated. The megaduodenum was about the same size as the somewhat dilated stomach. The peritoneal attachment of the duodenum extended up onto the under surface of the liver in the area of the porta hepatis. Further exploration of the peritoneal cavity revealed a Meckel's diverticulum and a rudimentary gallbladder.

The attachment of the duodenum to the right lateral posterior peritoneum was incised and this incision continued upward along the

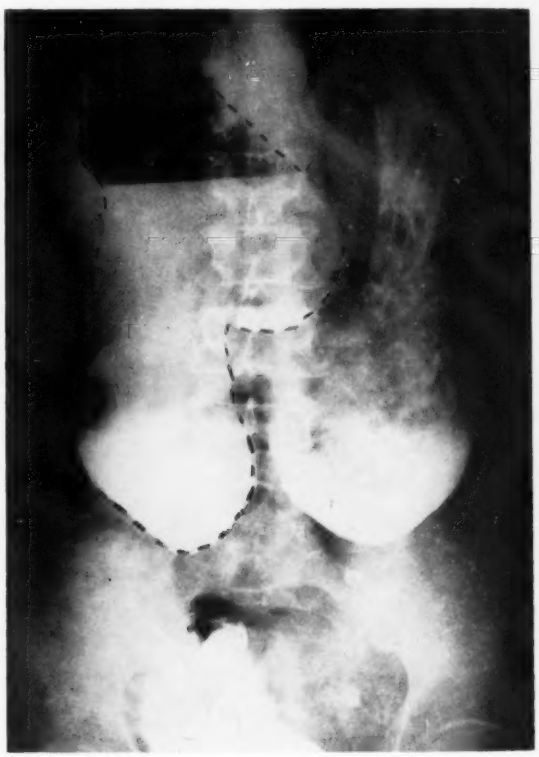

FIG. 1. Upright view showing marked dilatation of the duodenum (indicated by interrupted line drawing). The stomach is also dilated and contains a considerable amount of retained food.

abnormal peritoneal attachments of the duodenum to the under surface of the liver. During the mobilization of the duodenum, it was discovered that the right and left hepatic ducts were separate. The left hepatic duct was inadvertently severed. This required reimplantation end to side into the reconstructed duodenum. The gallbladder was removed and the miniature cystic duct and arteries separately ligated.

After complete mobilization of the duodenum, its paper-thin anterior and lateral walls were excised with the evacuation of a large amount of undigested food. Careful examination of the lumen of the duodenum failed to reveal an obstructing lesion. There was nothing to suggest extrinsic obstruction, such as that produced by annular pancreas or by pressure from the superior mesenteric vessels.

Following resection of the redundant portion of the duodenal wall, the remaining cut edges were approximated so as to form a duodenum of normal size. This repair was done with a continuous interlocked atraumatic chromic catgut suture for the mucosa, reinforced with interrupted cotton serosal sutures. The transected left hepatic duct was reanastomosed to the duodenum. The appendix was removed prophylactically. A rubber tissue drain was placed through a stab wound in the right flank down into Morrison's pouch. The patient's condition throughout the operation was quite satisfactory.

Fig. 2. Appearance two months after operation. There is some distortion of the duodenum. Barium passed through this portion of the small intestine without difficulty.

Fig. 3. Three years and ten months after the operation. Other than for a moderate tortuosity of the second portion of the duodenum, both the stomach and duodenum had a normal appearance at the time of this examination.

There was a febrile postoperative course, maximum temperatures reaching 102°F. Penicillin and streptomycin were used for the first thirteen postoperative days. Thereafter, aureomycin was substituted. The patient's diabetes was controlled with appropriate doses of insulin. The patient was discharged from the hospital on the twenty-third postoperative day. At that time he was eating a full diet and had been afebrile for five days.

This patient has been followed for four years. Two months after the operation there was some distortion of the duodenum, but no obstruction or recurrent dilatation (Fig. 2). At the present time the patient has no complaints referable to the gastrointestinal tract. The appearance of his duodenum is very nearly normal (Fig. 3).

DISCUSSION

The literature contains many descriptions of duodenal obstructions in infants.[1,12,16,19,20] In most instances the obstructions have been due to atresias, stenoses, or congenital bands. Less common causes are: abnormal fixation of the duodenum permitting volvulus, annular pancreas, vascular anomalies, and cysts of the mesentery, liver or pancreas. There is usually vomiting after each feeding. This begins soon after birth. The infant loses weight rapidly and becomes dehydrated. Unless these obstructive lesions are recognized promptly and treated surgically, it is unusual for the infant to survive more than a week or two. If the obstruction is complete, the diagnosis can be made from the plain roentgenogram of the abdomen because of the absence of air in the portion of the gastrointestinal tract distal to the duodenum. Incomplete obstructions may be demonstrated by means of lipiodol administered orally.

Megaduodenum in the adult is rare. Its etiology may be classified as follows:

1. Congenital
   - A. Intrinsic
     - a. Diaphragms or valves
   - B. Extrinsic
     - a. Duodenal bands or persistent cholecystoduodenocolic membrane
     - b. Annular pancreas
     - c. Aberrant superior mesenteric vessels
     - d. Faulty rotation of the intestine
     - e. High fixation of the ligament of Treitz with acute angulation of the duodenum
2. Acquired
   - A. Intrinsic
     - a. Tumor
     - b. Ulcer in second or third portion of duodenum or in upper jejunum
     - c. Foreign bodies
   - B. Extrinsic
     - a. Tumor or enlarged lymph nodes
     - b. Inflammatory or postoperative adhesions
     - c. Arteriomesenteric occlusion
3. Idiopathic

Congenital intrinsic obstructions of the duodenum are due to the fact that the primitive gut closes solidly when the embryo reaches the age of five weeks. This is brought about by the proliferation of epithelial cells. Later there is a process of vacuolization by which the lumen is reestablished. Congenital diaphragms or valves usually produce symptoms in infacy; however, a few cases have been reported in which megaduodenum in the adult has been on this basis.[8,15] A case of intermittent duodenal obstruction in an adult produced by an intraluminal diverticulum has been reported.[13] This diverticulum was thought to have arisen from some remnant of a duodenal diaphragm.

Congenital extrinsic lesions which obstruct the duodenum also are more likely to become manifest early in life. Occasional cases are reported in which obstruction in the adult is due to duodenal bands,[19] aberrant superior mesenteric vessels which compress the horizontal portion of the duodenum,[5] annular pancreas,[6] faulty rotation of the gut or acute angulation of the duodenum because of high fixation of the liagment of Treitz.

Of the acquired lesions obstructing the duodenum, carcinoma of the head of the pancreas with secondary invasion of the duodenum is the most common.[21] Obstruction of the duodenum by primary tumors, either benign or malignant, is rare. Another rare cause of megaduodenum is scarring secondary to ulcers of the distal portion of the duodenum or proximal jejunum.[7,21] Occasionally, adhesions in the region of the duodenum will produce obstruction. In a few instances enlarged lymph nodes have exerted enough pressure on the duodenum to obstruct it.[4,13,17] The enlargement of the lymph nodes has been due to such diseases as metastatic carcinoma, lymphosarcoma, Hodgkin's disease and tuberculosis.

During the early part of the century many papers were written about chronic arteriomesenteric occlusion of the duodenum. In this condition the horizontal portion of the duodenum is compressed between the spine and aorta posteriorly and the root of the mesentery, containing the superior mesenteric artery, vein and nerve, an

teriorly. It usually occurs in asthenic individuals with lordosis and visceroptosis. Although this diagnosis was quite popular for a time, it is now thought that this type of obstruction of the duodenum is rare.

A few cases have been reported in which there has been no apparent reason for the dilatation of the duodenum.[11,18] Our case falls into this group. Sturtevant[24] mentions the possibility of megaduodenum being comparable to megacolon. In cases of megacolon it has been observed that there is atrophy and dissolution of the plexuses of Meissner and Auerbach.[3] Such changes have not been reported in megaduodenum. These plexuses were normal in the duodenum of our patient. Because of the other congenital abnormalities of the gastrointestinal and biliary tracts of our patient, it is possible that the megaduodenum may have been of congenital origin. It is conceivable that a diaphragm or valve may have been present, which was obliterated when the duodenum became markedly dilated.

The symptoms associated with megaduodenum in the adult vary considerably. There is usually epigastric discomfort. This varies from a sense of fullness to a dull ache. Belching, nausea and vomiting are present in most cases. There may be toxic manifestations such as headache, lassitude and lack of concentration.

The diagnosis of megaduodenum by roentgenologic examination usually is not difficult. If there is dilatation of both the stomach and duodenum, it may be more difficult to definitely establish the identity of the dilated loop of the small intestine. At the time we first examined our patient, the dilated stomach contained a considerable amount of food. Only a small amount of barium could be forced into the duodenum. After the stomach contents had been aspirated, a more satisfactory examination was possible.

Surgical therapy for the relief of this condition has consisted primarily of duodenojejunostomy to relieve the duodenal stasis, or diverting operations such as gastroenterostomy or partial gastrectomy. There have been frequent failures. Dudley[9] reports a case in which there was still gastric stasis after five operations. These included duodenojejunostomy, gastrojejunostomy and jejunojejunostomy. Gastroenterostomy has been used to relieve the obstruction due to annular pancreas; however, the results have been unsatisfactory in a significant number of cases. More recently, subtotal gastrectomy has been recommended. It produces better results because of the more radical by-passing of the duodenum and the more direct reestablishment of the continuity of the gastrointestinal tract. We have been unable to find any previous record of correction of megaduodenum by plastic repair of the duodenum.

SUMMARY

A case of megaduodenum in a sixty-one year old man is reported. This condition was corrected by a plastic reconstruction of the duodenum.

Megaduodenum in the adult is rare. A few cases have been due to congenital abnormalities. These include intrinsic diaphragms, duodenal bands, annular pancreas and aberrant mesenteric vessels. Duodenal obstruction in the adult is more likely to be due to an acquired lesion, the most common of which is carcinoma of the head of the pancreas with secondary involvement of the duodenum. Other acquired lesions which may obstruct the duodenum include intrinsic tumors, ulcers of the second or third portions of the duodenum, and extrinsic bands or masses which exert pressure upon the duodenum. Among the latter are tumors, enlarged lymph nodes, inflammatory or postoperative adhesions, and the superior mesenteric vessels. In a few cases, such as ours, no obstructing lesion can be demonstrated.

The most common surgical approach to this condition has been duodenojejunostomy. Diverting operations, such as gastroenterostomy or partial gastrectomy, also have been used. We have been unable

to find any previous report of correction of megaduodenum by plastic repair of the duodenum.

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DUODENAL INVOLVEMENT IN REGIONAL ENTERITIS*

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IT IS not generally recognized that the duodenum may be involved in regional enteritis. The observation of 3 cases by the authors suggests that such involvement may be more common than is appreciated. It is believed that a presentation of these cases will emphasize the importance of examination of the upper alimentary tract in patients with regional enteritis and will facilitate recognition of this entity.

Since Crohn and his co-workers' initial description of regional enteritis in 1932,[5] numerous reports have appeared concerning the nature of the disease and its various sites of involvement; however, there has been a paucity of reports relating the disease to the duodenum. A survey of the literature revealed only 18 previously reported examples of this entity.[1–4,7–9] Of this group, 5 showed involvement of the duodenum without demonstrable involvement of the remainder of the small intestine, whereas in the remaining 13 there was involvement of other portions of the small intestine as well. The roentgen characteristics of these cases are similar to those encountered in cases included in this report.

REPORT OF CASES

CASE I. G. W., twenty-four year old white female, was admitted in April of 1949, with an eight year history of diarrhea. In 1946, following an episode of diarrhea, an appendectomy was performed at another hospital. At surgery the ileum showed changes considered typical of regional enteritis.

The patient did well until 1953, when there was recurrence of diarrhea associated with epigastric pain, fever, and weight loss. An examination of the upper gastrointestinal tract performed elsewhere was reported as showing inflammatory changes in the duodenum. Following institution of an elimination diet, her symptoms were partially alleviated.

One month prior to admission she experienced an exacerbation of symptoms. The severity of her diarrhea increased with associated lethargy, anorexia, nausea, and vomiting.

On admission the patient appeared chronically ill. Physical and laboratory examinations were not remarkable. Roentgenologic examination of the upper gastrointestinal tract demonstrated coarsening of the rugae of the stomach without evidence of retained secretions. The mucosal folds of the duodenum were distorted and irregular. The entire small intestine appeared irritable. The valvulae conniventes of the terminal ileum were thickened and there was narrowing of the lumen in several areas (Fig. 1).

CASE II. G. F., thirty-four year old male, was first seen in November of 1954, complaining of periodic diarrhea and epigastric pain since the age of fourteen.

On admission the only positive physical finding was a mild dermatitis involving the head and neck. Laboratory examinations, including hemogram, urinalysis and stool studies, were within normal limits.

Roentgen examination of the upper gastrointestinal tract revealed unusual prominence of the gastric rugae. The duodenal bulb had a normal appearance, but the caliber of the lumen of the remaining portion of the duodenum was increased and the mucosal pattern distorted. There was alteration in the mucosal pattern of the entire small intestine, the changes increasing in severity in the more distal portions of the intestine (Fig. 2). The roentgen changes were considered typical of regional enteritis.

CASE III. M. M., twenty-nine year old white male, was first seen in 1949, complaining of epigastric and periumbilical pain of eight months' duration. This was accompanied by vomiting, and the vomitus frequently contained undigested food particles. Stools were normal. Since the onset of his illness he had had a 50 pound weight loss.

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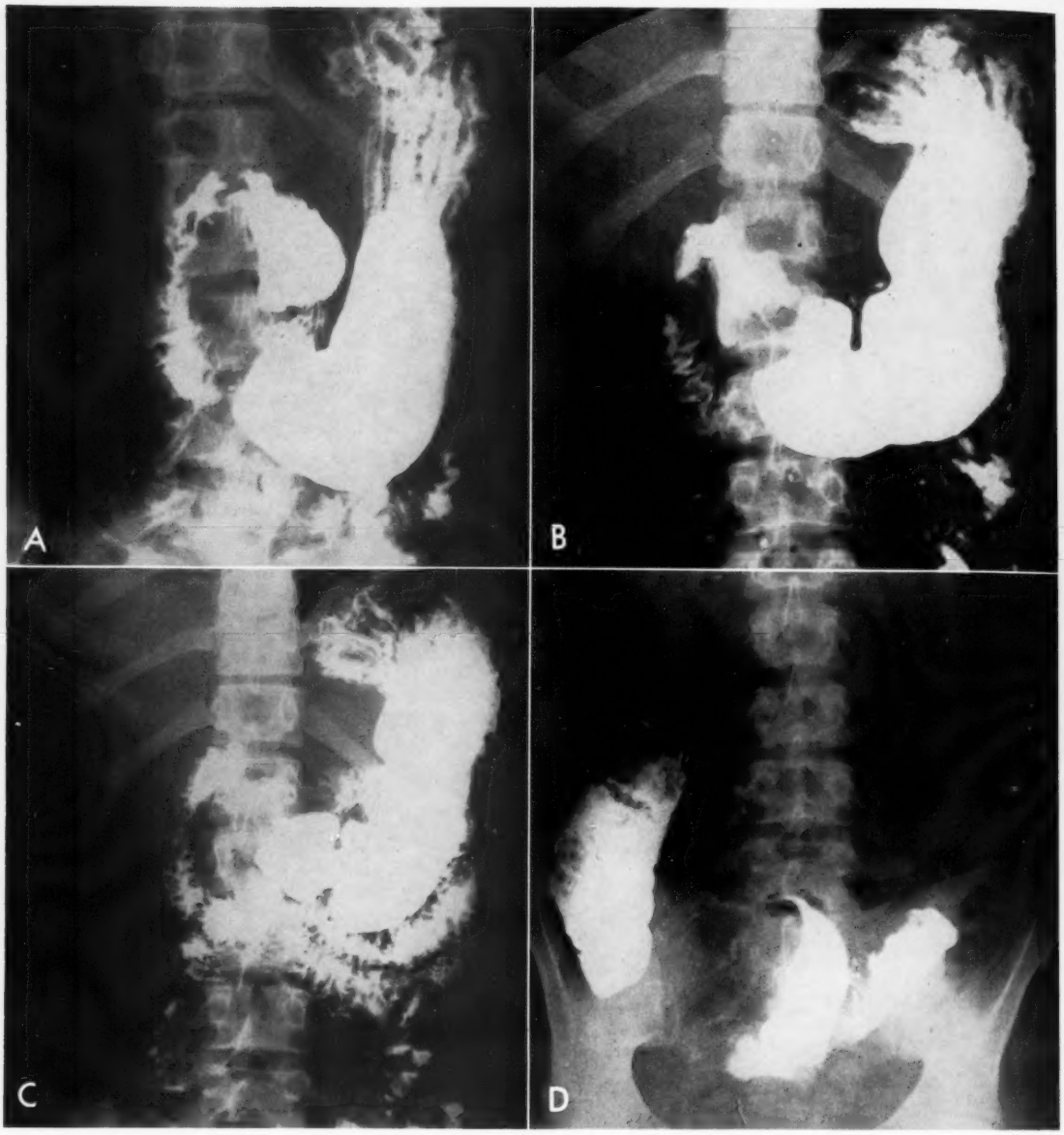

Fig. 1. Roentgenograms showing regional enteritis involving the entire small intestine. (*A*) Coarsened ruga pattern of the stomach. (*B*) Distorted mucosal pattern of the duodenum. (*C*) Thickening and distortion of the mucosal folds of the jejunum indicating involvement by the inflammatory process. (*D*) Advanced regional enteritis of the ileum showing both dilatation and stenosis of various portions of the intestine.

Admission physical and laboratory examinations were within normal limits, except for a mild microcytic anemia.

Roentgen examination of the upper gastrointestinal tract demonstrated a coarse irregular mucosal pattern of the stomach and duodenum. The mucosal pattern of the entire small intestine showed similar changes. The wall of the terminal ileum had lost its pliability and its lumen was attenuated (Fig. 3, *A* and *B*).

The patient was placed on a low residue diet and steroid therapy. He experienced periodic exacerbations of his illness and, in 1951, developed a periappendiceal abscess which required surgical intervention. At laparotomy inflammatory changes in the small intestine were noted from the ligament of Treitz to the cecum. Pathologic examination of tissue obtained from the terminal ileum and jejunum showed chronic inflammation typical of regional enteritis.

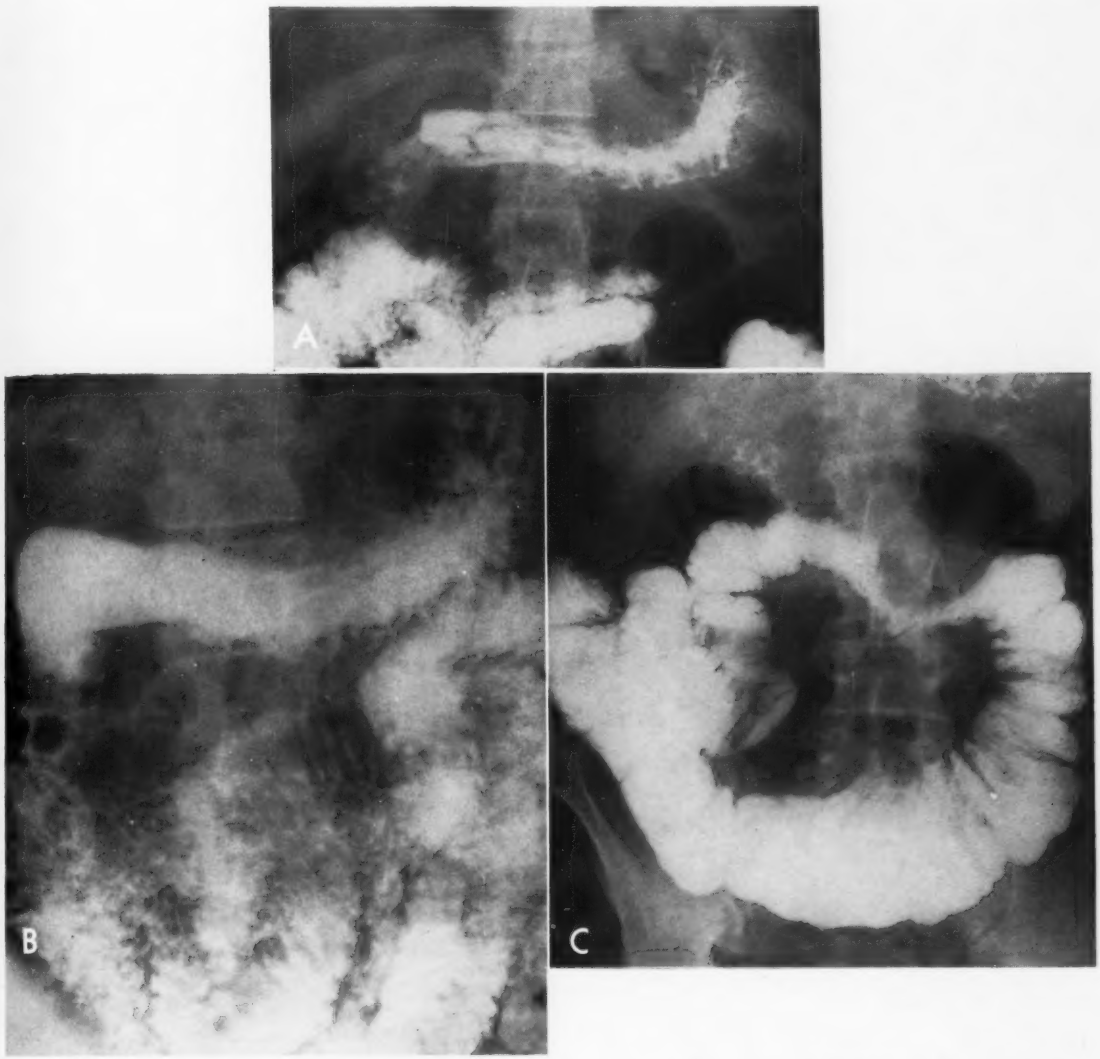

Fig. 2. Roentgenograms showing regional enteritis of the entire small intestine. (*A*) Coarsened rugal pattern of stomach. (*B*) Increased caliber of the lumen and distorted mucosal pattern of duodenum and jejunum. Note polypoid appearance of second portion of the duodenum. (*C*) Dilatation and coarsening of mucosal pattern of the ileum.

In 1952, hospitalization was necessitated by epigastric pain and vomiting following meals. The patient's stools were loose, but there was no diarrhea. Gastrointestinal series at this time revealed partial gastric retention. The bulb was large and flaccid, and the duodenal loop was dilated. The lumen was narrowed at the junction of the second and third portions (Fig. 3 *C*).

At operation marked inflammatory involvement of the duodenum was observed with stricture at the junction of the second and third portions. A gastrojejunostomy was performed.

The patient has been followed at close intervals and has done well on steroid therapy.

DISCUSSION

The roentgen findings of regional enteritis of the duodenum do not differ from those associated with involvement of other portions of the small intestine. The changes are those associated with inflammation; namely, blunting, thickening and irregularity of the mucosal folds. As the disease progresses the mucosa may assume a polypoid appearance due to the presence of islands of hyperplastic mucosa. In the late stages of the disease the intestine be-

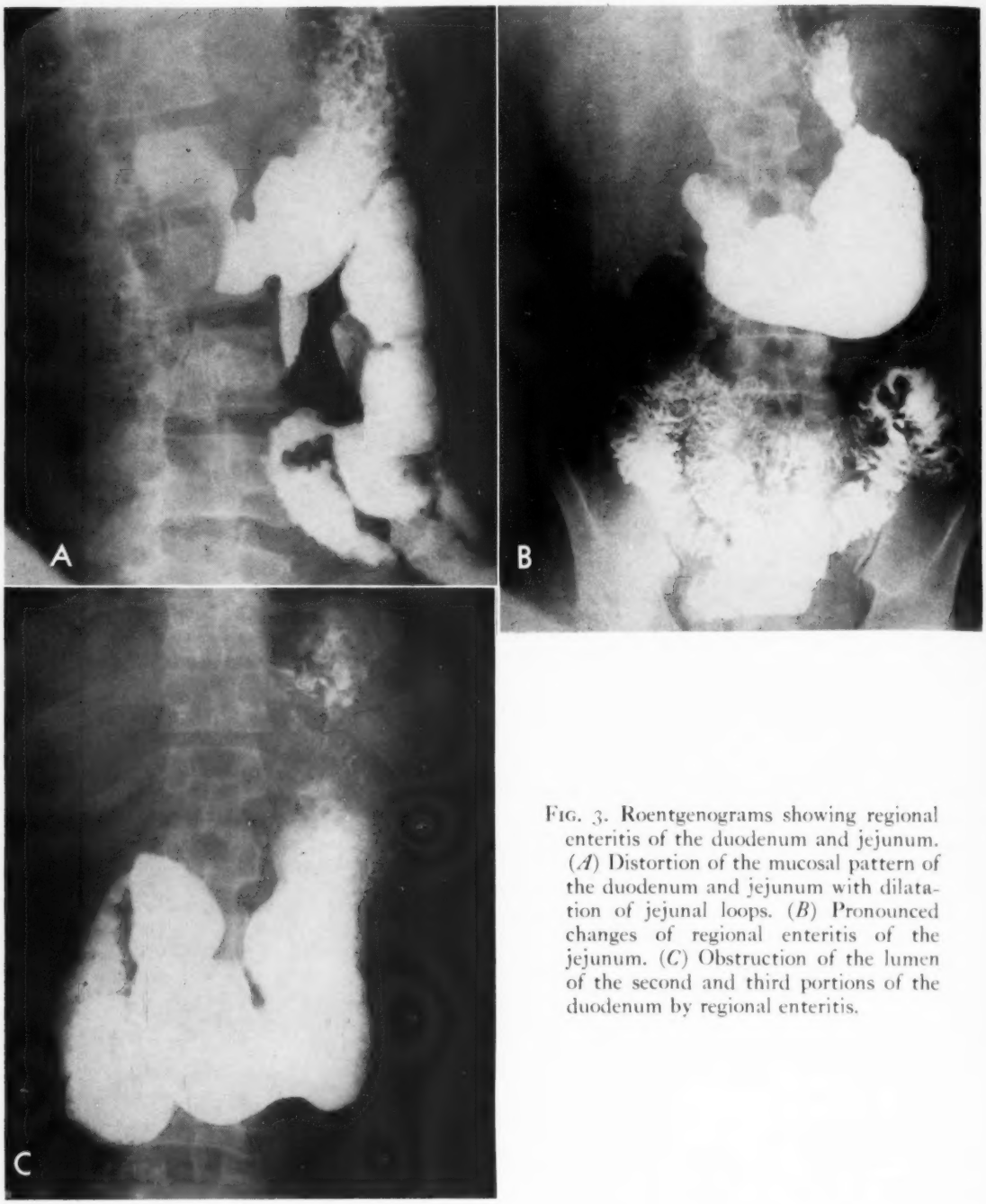

Fig. 3. Roentgenograms showing regional enteritis of the duodenum and jejunum. (*A*) Distortion of the mucosal pattern of the duodenum and jejunum with dilatation of jejunal loops. (*B*) Pronounced changes of regional enteritis of the jejunum. (*C*) Obstruction of the lumen of the second and third portions of the duodenum by regional enteritis.

comes scarred and may become stenotic.

Isolated involvement of the duodenum by regional enteritis may present a difficult diagnostic problem. In such cases peptic duodenitis, lymphosarcoma and carcinoma of the duodenum, carcinoma of the ampulla of Vater, carcinoma of the pancreas with duodenal invasion, pancreatitis and hypertrophy of Brunner's glands must also be considered. When other segments of the small intestine are involved by the inflammatory process, the diagnosis may be made with relative ease. Tuberculosis of the small intestine may

simulate regional enteritis, but duodenal involvement in the former condition is unusual. Tuberculous enteritis is commonly associated with pulmonary lesions.

Cases have been reported[4,9] in which there was histologic evidence of involvement of the stomach by regional enteritis. In 2 of the 3 cases reported here, there was alteration of the mucosal pattern of the stomach. However, we believe that these are nonspecific and probably do not represent actual gastric involvement by the inflammatory process. This impression was confirmed at surgery in Case III.

In the cases reported, the usual symptomatology of regional enteritis was present. In addition, all patients complained of epigastric distress which in two of the patients was associated with nausea and vomiting. Such symptoms are not an important part of the symptomatology of the usual patient with regional enteritis without obstruction. We suspect that these symptoms are an indication of involvement of the proximal small intestine. This is substantiated by other reported cases of duodenal and high jejunal involvement.

The data presented suggest that examination of the stomach and duodenum should be included in patients with regional enteritis.

SUMMARY

1. Three cases of regional enteritis involving the duodenum have been presented. It is suggested that such involvement may not be as rare as the paucity of reports in the literature would indicate.

2. The roentgen characteristics of regional enteritis of the duodenum are similar to those elsewhere in the small intestine.

3. It is postulated that the symptoms of epigastric distress associated with nausea and vomiting indicate involvement of the proximal small intestine, particularly the duodenum, by the inflammatory process.

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The authors wish to express their appreciation to the members of the Department of Medicine of the University of California School of Medicine for the clinical data used in this paper.

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MECKEL'S DIVERTICULUM

REPORT OF A CASE DEMONSTRATED ROENTGENOLOGICALLY

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MECKEL'S diverticulum is a developmental malformation resulting from the persistence of the intra-abdominal part of the vitello-intestinal or the omphalomesenteric duct. In the early fetal life this duct joins the mid-gut with the yolk-sac. Under normal circumstances, as the growth continues, this communication becomes obliterated and entirely disappears. At times, this normal event may fail, and depending on the stage at which the failure of normal obliteration occurs, several types of anomalies may develop. Of the various malformations Meckel's diverticulum is by far the most common. It may be cylindrical, conical or cord-like, and it may present secondary diverticula near its tip.

About 2 per cent of the population have been estimated to be affected by this anomaly.[5] Cunningham[1] reports that in 3,302 cadavers specially examined with reference to its existence, it was present in 73, or 2.2 per cent. Haber[4] has collected several autopsy series from the literature in which the incidence varied between 0.1 and 2.7 per cent. In 10,000 consecutive autopsies at the Johns Hopkins Hospital[9] (1929–1947), the lesion was present in 103, an incidence of 1.0 per cent. It appeared to be more common in the male than in the female, in a ratio of 3 to 1.

Wilson[10] estimated that 20 per cent of all the affected cases develop symptoms and complications.

A large number of cases remains clinically asymptomatic. In spite of the fact that a certain number of these asymptomatic cases may be undergoing roentgen studies of the gastrointestinal tract for one reason or another, the roentgen demonstration of Meckel's diverticulum is admittedly rare. Credit for the first roentgen demonstration of Meckel's diverticulum goes to Pfahler,[7] who reported 2 cases in 1934; one he had identified in 1923 and the other in 1931. Since that time about 22 cases have been reported in the literature, in which the diverticulum has been demonstrated by roentgenologic means. The present case, where the Meckel's diverticulum was discovered incidentally, is an addition to the literature.

REPORT OF A CASE

A young boy, aged eleven, had a history of acute pain in the right iliac fossa since July 8, 1954. There was no fever or vomiting. He was treated with antibiotics and the pain subsided in about eight days.

FIG. 1. Roentgenogram taken four hours after ingestion of barium meal. A diverticulum is seen as an isolated pouch in the midabdominal region.

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Roentgen study of the gastrointestinal tract was undertaken on September 24, 1954. The esophagus, stomach and duodenum revealed no abnormality. Roentgenoscopic and roentgenographic examination, four hours after the ingestion of the barium meal, showed a smooth isolated pouch located anteriorly in the mid-abdominal region. The small intestine was empty. The whole of the colon was visualized. The cecum was placed in the right lumbar region about 8 cm. above the level of the iliac crest. The appendix was well filled, tender and seemed to be adherent. The pelvic colon was redundant and was located in the right iliac fossa.

At twenty-four and thirty hours the previously noted pouch was still seen retaining the barium, and, while turning the patient to the right, a small amount of barium was seen trickling down the pouch through a tube-like structure as shown in Figure 3. The appendix showed stasis.

The roentgen impression was that the appendix was adherent, tender and showed stasis suggestive of a pathologic process. An isolated pouch, located anteriorly in the mid-abdominal region and retaining the barium for over thirty hours, indicated the presence of a Meckel's diverticulum.

Fig. 3. Same as Figure 2, with the patient prone in slightly oblique position.

Fig. 2. Roentgenogram taken 24 hours after ingestion of barium meal with the patient in supine position, showing the entire length of the Meckel's diverticulum with bulbous dilatation at its tip.

Laparotomy was performed on October 19, 1954. A Meckel's diverticulum with a bulbous terminal end was seen arising from the antemesenteric border of the ileum. It was about 11 cm. long and was placed approximately 60 cm. proximal to the ileocecal junction. The appendix was partly retrocecal, inflamed and adherent. An appendectomy and a diverticulectomy were performed.

SUMMARY

A case with roentgen visualization of a Meckel's diverticulum has been presented.

The entire length of the diverticulum with a secondary diverticulum at its tip has been demonstrated clearly. It had the characteristics of an ordinary diverticulum, but its configuration and anterior location in the midabdominal region proved helpful in arriving at the correct diagnosis.

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I wish to thank Dr. N. D. Patel, M.D. (Lond.), M.R.C.P. (Lond.), Dean, King Edward VII Memorial Hospital, Bombay, for allowing me to reproduce the roentgenograms, and Dr. Z. J. Joseph, M.D., D.M.R.E. (Cantab.) and Dr. L. H. Athle, M.B.B.S., D.M.R. (England), M.A.C.R., Honorary Radiologists, K.E.M. Hospital, Bombay, for their encouragement and suggestions.

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Vol. 77, No. 4

MUCOCELE OF THE APPENDIX*

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MUCOCELE of the appendix is a cystic dilatation of the vermiform appendix, containing a gelatinous mass called mucin or pseudomucin. Historically, the literature has been well reviewed in the past few years. Detailed description by Rokitansky[10] in 1849 and Virchow[12] in 1863 established the pathogenesis of mucocele formation. The term mucocele was not applied to this condition until Féré[5] in 1877 dissected a fusiformly enlarged appendix which contained a gelatinous mass that proved to contain mucin. The literature did not refer to this condition for fifty years, and only since Åkerlund's[1] description in 1936 has interest been renewed in the attempt to diagnose mucocele formation preoperatively. Woodruff and McDonald[14] reviewed the incidence of mucocele of the appendix at the Mayo Clinic over a period of twenty-four years. They found the frequency to be 0.3 per cent of the appendices removed at that institution.

Bonann and Davis[2] state that there are over 500 cases reported in the literature. However, only 5 cases have been preoperatively diagnosed.[4,8,11,12] This lesion is not rare.

Despite the establishment of roentgenologic criteria for the diagnosis, the preoperative diagnosis is seldom established. The early diagnosis of this lesion is significant when one is acquainted with the case reports of Johnston,[6] and Jones and Carmody[7] in which such complications of mucocele as (1) pseudomyxoma peritonei, (2) acute inflammation, (3) intussusception, (4) volvulus, and (5) carcinoma were described.

The purpose of this paper is to re-emphasize and suggest further roentgenologic diagnostic criteria and to present a case of mucocele of the appendix which had unusual pathologic facets.

REPORT OF A CASE

S. G., a sixty-six year old white male, was admitted to Beth Israel Hospital with complaints of rectal pain, constipation, and pruritus of three to four years' duration.

The past history included a prostatectomy nine years prior to admission, and an operation for diverticulitis two years prior to admission. The physical examination was entirely normal, except for a rectal fissure. The laboratory findings were normal, including stool examination which did not reveal any blood. A barium enema study demonstrated a sharply circumscribed polypoid filling defect in the cecal pouch distal to the ileocecal valve. Compression studies of this region showed vortical folds of the mucosa. The mass appeared relatively radiolucent and was only slightly more dense than the surrounding air on contrast studies. A small amount of barium entered the appendix. A lipoma was suggested because of the radiolucency of the mass and the sharply circumscribed folds of mucosa about the tumor as seen in the extramucosal lesion (Fig. 1, 2 and 3).

At operation the cecum and the terminal ileum were adherent to the surrounding peritoneum on both anterior and lateral walls. When the cecum and ascending colon were mobilized, a mucocele of the appendix was discovered indenting the cecal wall. An appendectomy was done, with removal of a portion of the cecal wall.

The pathologic report (by Dr. D. Dreizin) described the serosa of the appendix as partially covered by fibrinous and fatty strands and containing several mucus filled nodular protusions, ranging from 0.5 to 1.0 cm. in diameter. The appendix measured 9.5 cm. in length and up to 2.5 cm. in diameter. The wall measured 0.2 cm. in thickness. The lumen contained tenacious mucinous material which bulged into the wall, forming nodular protrusions. The diagnosis was mucocele of the appendix (Fig. 4).

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Fig. 1. Compression studies of the cecal pouch showing the polypoid filling defect and vortical mucosal folds as indicated by the broad arrow.

DISCUSSION

The clinical symptoms of uncomplicated mucocele are vague and often absent. The roentgenologic examination serves as the only method of diagnosis. Perhaps the best review for roentgen findings was presented by Åkerlund.[1] In it he established the following roentgen characteristics in mucocele of the appendix: (1) absence of filling of the appendix; (2) rounded, sharply outlined reniform soft tissue shadow in the cecal region, without connection to a parenchymatous organ; (3) demonstration

Fig. 2. The filling defect is again demonstrated at the tip of the cecal pouch.

Fig. 3. Air contrast studies of the cecum fail to show the filling defect; however, the appendix is visualized by the barium.

Fig. 4. Serosal aspect of the appendix.

of calcium deposits in the mass; (4) medial displacement of the cecum. Vorhaus[13] described the vortical appearance of the mucosal folds as a fifth criterion for roentgen diagnosis. Buckstein[3] remarks that the primary evidence of a mucocele is a pressure defect involving the lower pole of the cecum, indistinguishable from that produced by any extracecal mass. This may be true in many instances. However, we feel, after careful evaluation of our case and study of roentgenograms from previous publications, heretofore unrecorded roentgenologic signs should be included as an aid to diagnosis. Distensibility of the cecum is a significant roentgen finding. Since inflammatory reaction is absent in uncomplicated cases of mucocele, the contiguous cecum behaves as an inert pouch and is unlikely to be irritable. Thus, roentgenologically the cecal pouch on repeated examinations distends well except for the pressure defect on the lower pole made by the cystic mass. Distensibility, therefore, helps to exclude a contiguous inflammatory mass, such as a specific granuloma, appendiceal abscess, localized peritonitis or neoplastic infiltration of the cecum. Another roentgen sign, the vortical appearance of the cecal mucosa previously described by Vorhaus,[13] deserves re-emphasis. These changes are anticipated in an extramucosal, closely adherent mass. Compression studies demonstrated these changes in the cecal pouch on barium enema study. It is of interest that microscopic and gross examinations of the appendix in our patient failed to disclose complete occlusion of the base or the neck of the appendix as anticipated. The pathogenesis of mucocele formation is well established as chronic obstruction, usually fibrosis, occluding the lumen of the appendix. The only other reported case in the literature in which the lumen of the appendix was patent and actually filled with barium was by Vorhaus[13] in 1930. This case is also unique in that pathologically, this mucocele had mucinous nodular formation in the crypts and extending to the serosa of the appendix. The pathologists feel that such changes may be the precursor of globoid body formation reported by Milliken and Poindexter.[9] The pathogenesis of this type of mucocele is thought to be cryptic inclusions of mucin in the wall. Mucin is transformed to pseudomucin and discharged into the lumen of the appendix as globoid bodies.

SUMMARY

1. A review of the roentgenologic criteria established by Åkerlund for diagnosing mucocele of the appendix is presented.

2. The authors add a new roentgen sign as an aid in the diagnosis.

3. A case of mucocele of the appendix is cited in which no obstruction to the neck of the appendix was found and cryptic inclusion of mucin was present in the wall.

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THE MUCOSAL PATTERN OF THE MESENTERIC SMALL INTESTINE—AN ANATOMIC STUDY*

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THE mesenteric small intestine extends from the duodenojejunal flexure to the ileocolic junction. Roentgenologists study it daily, either in the performance of upper gastrointestinal tract examinations, so-called small intestinal series or in retrograde filling during barium enema studies. In spite of this familiarity and a reasonably voluminous literature, it continues to be the uncharted wilderness of the intestinal tract. Some of the reasons for this are obvious. Its length, relative lack of fixation save at its origin and termination, the tendency of closely associated loops to overlap and obscure each other and the absence of abrupt and permanent anatomic changes along its length under normal circumstances all hinder easy study by roentgenologic means. In addition, if one excludes mechanical obstruction due to extrinsic causes, there is a relatively low incidence of roentgenologically demonstrable organic pathology involving the mesenteric small intestine as compared with other segments of the intestinal tract. The evaluation of so-called functional disturbances is at best an uncertain matter with present techniques of examination.

Of equal importance, however, is our ignorance concerning many of the fundamental anatomic and physiologic aspects of the normal mesenteric small intestine. Its basic divisions and structure can be found in any standard anatomic or histologic text. Anyone familiar with the complex picture of the small intestinal mucosa as visualized roentgenologically, however, will be struck by the total inadequacy of of the descriptions and illustrations of the gross mucosal patterns as found in these works.[2,4,10,12]

Numerous articles have been published dealing with the roentgenologic appearance of the normal small intestinal pattern,[3,5,8,9,13,14] but there have been surprisingly few attempts to correlate these roentgenologic findings with the actual mucosal patterns as seen anatomically. Forssell[6,7] and Cole[15] were interested in the problem and wrote extensively on the nature of the mucosal patterns throughout the intestinal tract, but their published illustrations leave something to be desired, and they reached somewhat divergent conclusions as to the physiology of the changing mucosal folds and patterns.

The purpose of this article is to present a gross anatomic study of the mucosal patterns of the mesenteric small intestine, as seen in the adult human, and insofar as is possible to correlate the anatomic and roentgenologic appearances of these patterns.

METHOD OF STUDY

Under normal circumstances, there is no way to perform direct and careful visual studies on the mucosal patterns of the mesenteric small intestine in the living human. Enterostomies and laparotomies offer only limited opportunities for such studies. Therefore one is forced to study these patterns in the cadavers of the anatomic dissecting room or at the autopsy table. In the preserved cadavers of the dissecting room available for study, the small intestine was so distorted by postmortem and fixation artefacts as to be almost totally worthless. It is suspected that this accounts for the unsatisfactory illustrations and descriptions occurring in most anatomic texts. At the autopsy table

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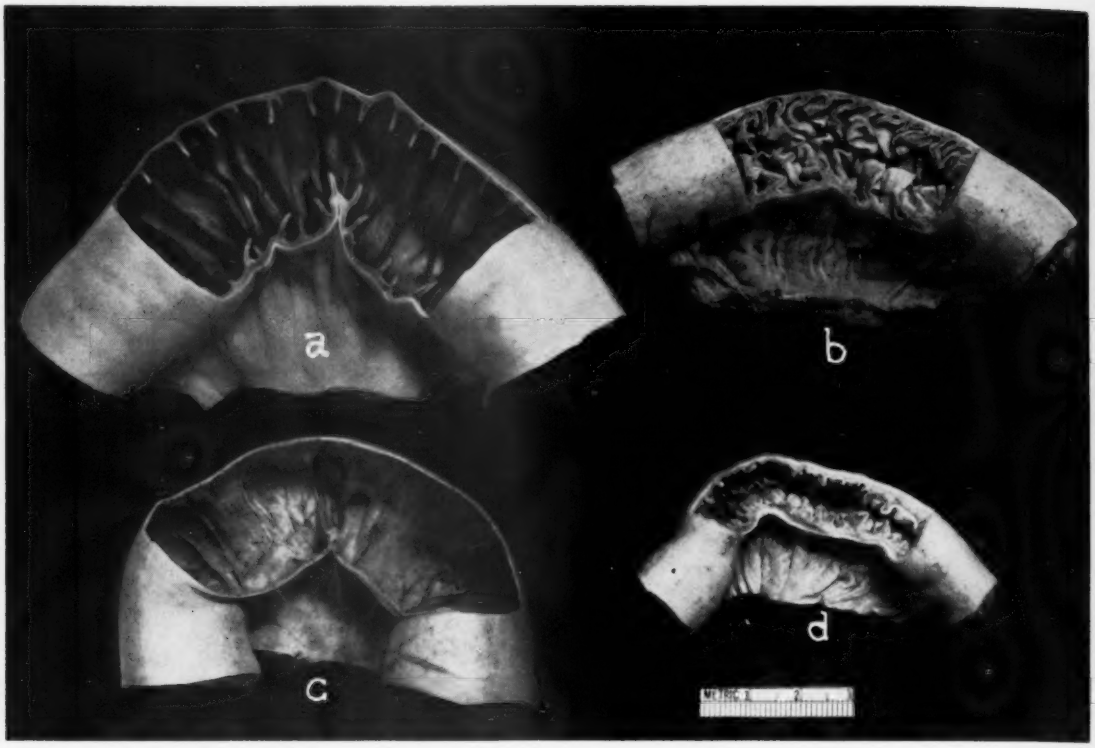

FIG. 1. (*a* and *c*) Specimen loops of jejunum and ileum which were found at autopsy to be moderately distended. The demonstrated mucosal patterns correspond well with those illustrations appearing in standard anatomic texts. (*b* and *d*) Specimen loops of jejunum and ileum found at autopsy in a good state of contraction. It is specimens of this type which were used for the most part in this study.

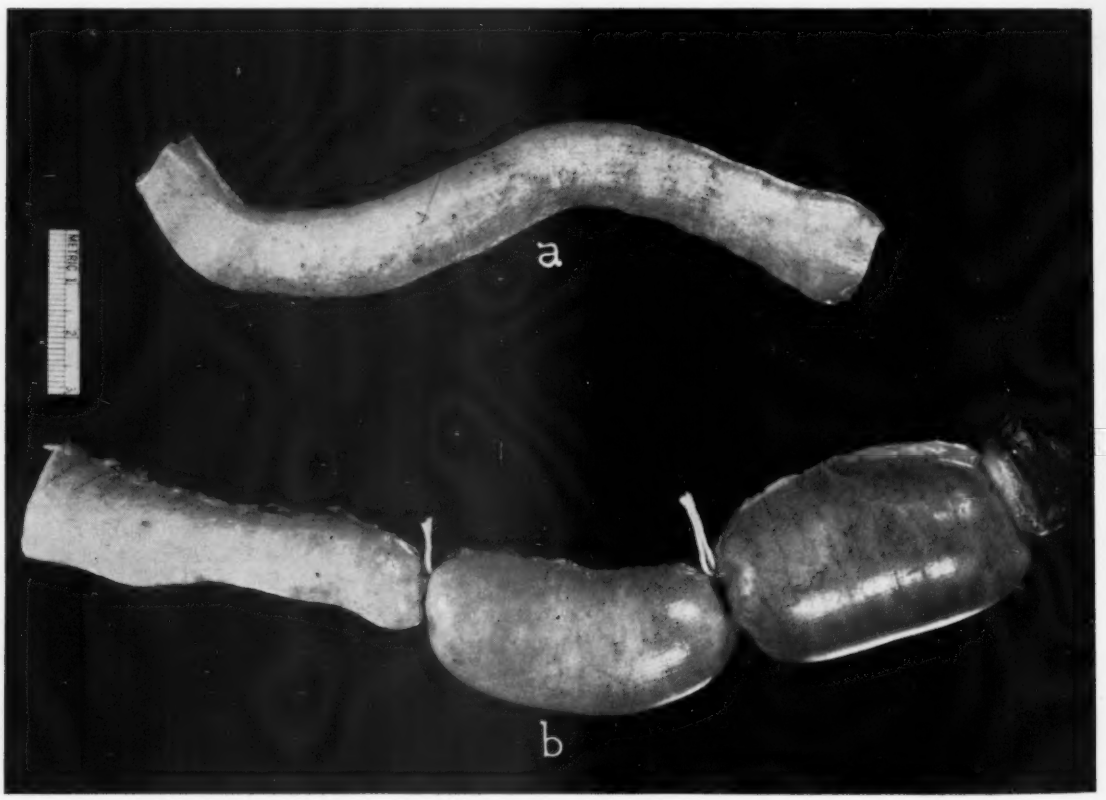

Fig. 3. Specimen loops of small intestine in which at autopsy there was an obvious and fairly abrupt change in lumen diameter. Such specimens were ligated and filled with formalin solution. After fixation for approximately twelve hours they were rigid enough to permit bivalving and trimming (*d* and *e*).

one may also find the small intestine grossly distorted by postmortem changes or disease processes, but there are instances in which segments of the intestine have a relatively undistorted and contracted appearance (Fig. 1,*b* and *d*). This is especially true in instances in which the autopsy is performed shortly after death. Only such grossly normal specimens from adult autopsies were used in this study.

The entire mesenteric small intestine may be easily removed from the cadaver with minimal trauma by dividing it close to its origin and termination and then cutting across the base of its mesentery. The specimen may then be lifted out as a block and various segments studied at will.

During the course of this study representative areas along the entire small intestine were examined, but findings will be reported only on segments from the proximal jejunum and distal ileum, since these reveal the range of greatest change in the mucosal patterns. The terminal few inches of ileum are not included in the current study.

Fig. 2. (*a*) A segment of jejunum found at autopsy in a good state of contraction. (*b*) A similar adjacent loop of jejunum from the same autopsy showing the manner in which such segments may be artificially distended. Distention was accomplished by passing a small needle through the wall and injecting the desired amount of formalin solution. Note the increase in the length of the specimen, which was initially the same length as the undisturbed segment above.

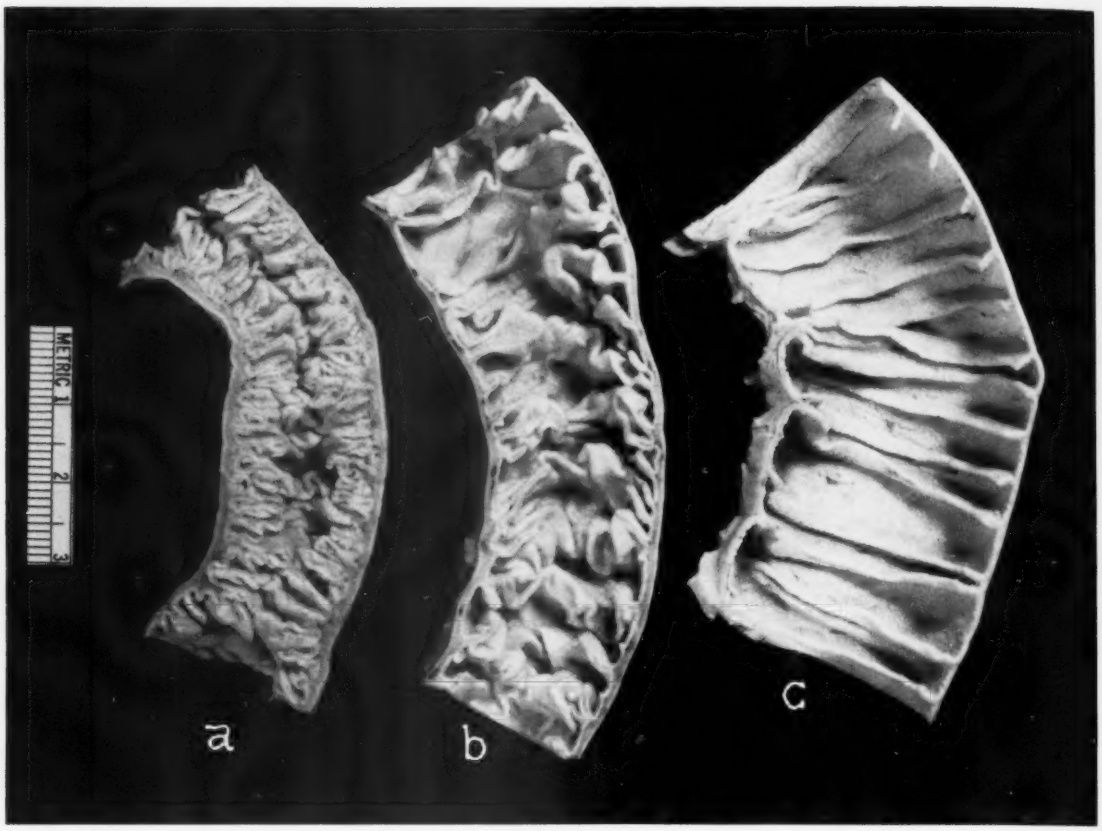

Fig. 4. Undisturbed specimens of jejunum taken from different autopsies showing the typical patterns of mucosal folds seen with firm contraction (*a*), intermediate relaxation or distention (*b*) and more marked distention (*c*). Note the difference in the gross mucosal patterns and the obvious association between these patterns and the size or lumen diameter of the central canal.

Loops to be studied were fixed and preserved in a 10 per cent formalin solution. In instances where loops were initially distended to various degrees with intestinal contents, these were first gently flushed out and the intestine redistended to its original degree with the formalin solution. After approximately twelve hours, the average specimen was rigid enough to permit bivalving and trimming.

Basically, the intestine was studied in three different situations. First, representative segments showing varying degrees of natural distention were examined. Second, initially contracted segments were artificially distended (Fig. 2) and finally, segments found at autopsy showing fairly abrupt changes from a contracted to a distended state were studied (Fig. 3). Representative specimens were photographed and emphasis will be placed on these, since it is felt that they convey the appearance of the gross mucosal patterns far better than any written description.

FINDINGS

A. *Jejunum.* Initially, many segments of upper jejunum were fixed in their undisturbed autopsy state. Later these specimens were studied as a group, and in Figure 4 are shown three representative specimens from different autopsies, revealing the range of mucosal patterns usually observed. It is immediately apparent that there is a marked variation in these patterns. Further study of the specimens revealed, as one might expect, a correlation between the pattern and the degree of distention of the

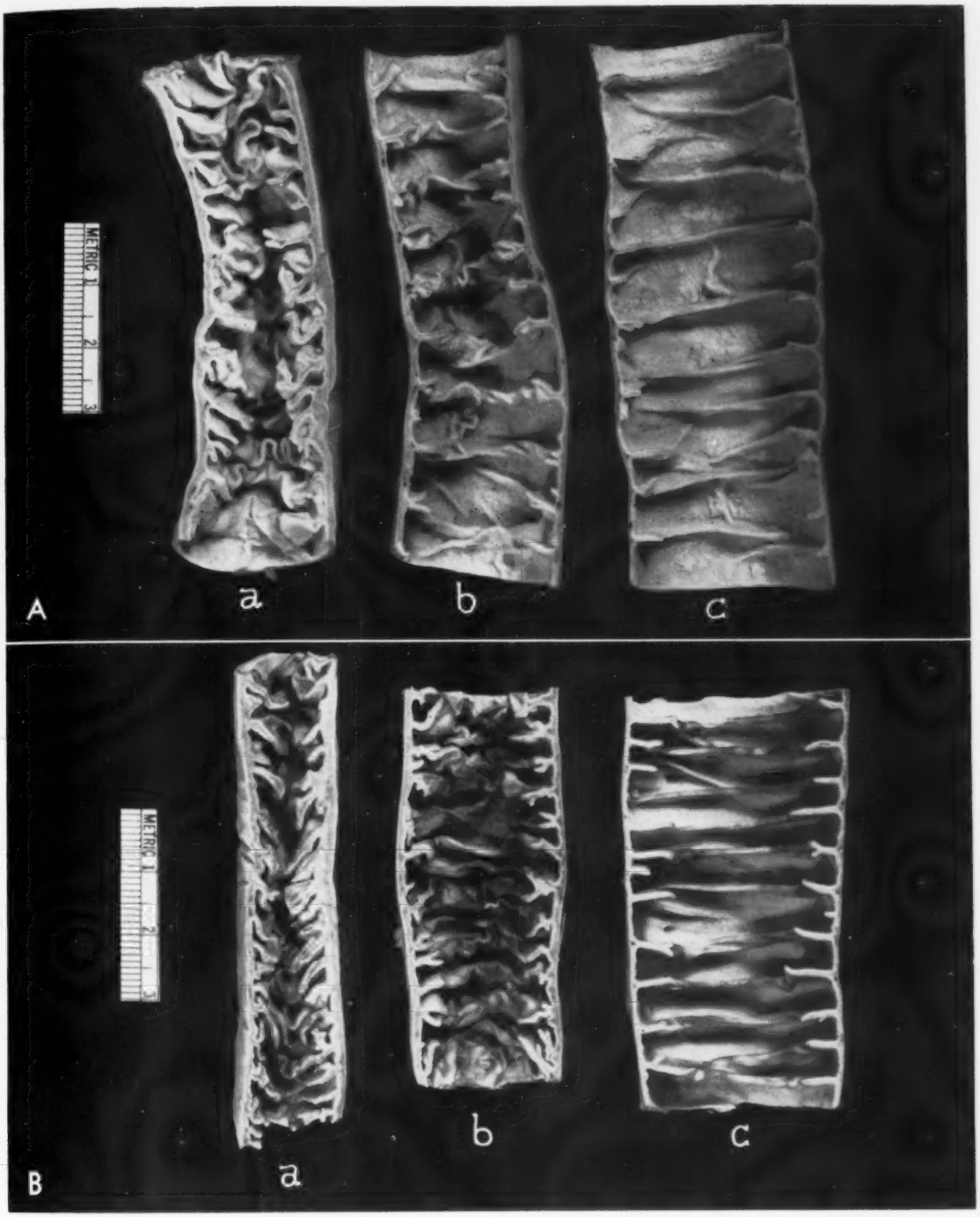

Fig. 5. (*A* and *B*) Jejunal mucosal patterns obtained with artificial distention of initially contracted segments. In both instances *a* represents the initial contracted state, and *b* and *c* progressive degrees of distention of immediately adjacent segments (see Figure 2 and text for manner in which this was done).

intestine. If at autopsy the specimen was found to be moderately distended by gas or other luminal contents, its mucosal folds were found to approximate those shown in Figure 4*c*. If, on the other hand, the segment of intestine selected was contracted with a thick wall and practically no intraluminal contents, its mucosal folds simulated those shown in Figure 4*a*. Intermediate stages of distention tended to reveal patterns similar to those shown in Figure 4*b*.

In an effort to further evaluate the role of distention upon the jejunal mucosal patterns, it was decided to artificially distend initially contracted loops, it being a simple matter to distend portions of such loops to varying degrees (Fig. 2*b*). As such segments were distended, it was noted that there was not only an increase in the diameter of the segment, but also an increase in its length. The effect of such distention upon the mucosal folds is well shown in Figure 5,*A* and *B*, and it will be seen that the patterns obtained correspond well with those observed in undisturbed autopsy specimens (Fig. 4). Figure 6 is a schematic illustration of the changes in the mucosal folds associated with distention of the jejunum.

Figure 7 represents roentgenograms of specimen loops of jejunum which have been distended to varying degrees with a barium suspension, the effect of distention on the mucosal pattern being well shown. Representative segments of jejunum in varying stages of distention as gathered from clinical roentgenographic studies are shown in Figure 8, and it will be noted that these patterns match reasonably well with those obtained from the autopsy specimens.

As one studies the mucosal patterns of contracted jejunal loops at autopsy, it is obvious that there is considerable difference in the size of individual folds from case to case. Figure 9*A* demonstrates some of these variations in fold size. Such variation is also noted in clinical roentgenographic studies, as shown in Figure 9*B*.

In any given instance at autopsy, the jejunum usually presents a relatively uniform degree of distention throughout its entire length, and in most instances, there is relatively little in the way of intraluminal contents. Occasionally, however, one finds short segments in which air or fluid have been trapped at the time of death. Figure 10,*A* and *B* shows such segments, and the abrupt change in mucosal patterns is well shown. Figure 10*C* demonstrates somewhat similar clinical patterns, although here peristaltic waves are also demonstrated.

B. *Ileum.* The distal ileum presents a distinctly different appearance from the upper jejunum, as is well known, both anatomically and roentgenologically. Perhaps the simplest mucosal pattern is found in instances where the ileum is moderately distended with intestinal contents. Representative undisturbed ileal autopsy segments, showing such distention, are shown in Figure 11*A*. Note the thin wall of the intestine under such conditions, the low, irregularly spaced mucosal folds typical of the distended ileum. Figure 11*B* represents clinical studies of moderately distended

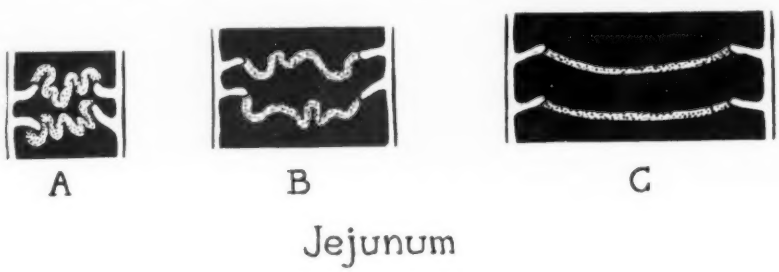

Fig. 6. A schematic representation of the basic change in the pattern of the jejunal mucosal fold secondary to increasing lumen diameter. Not only do the various secondary folds become obliterated, but the distance between the major circular folds also increases.

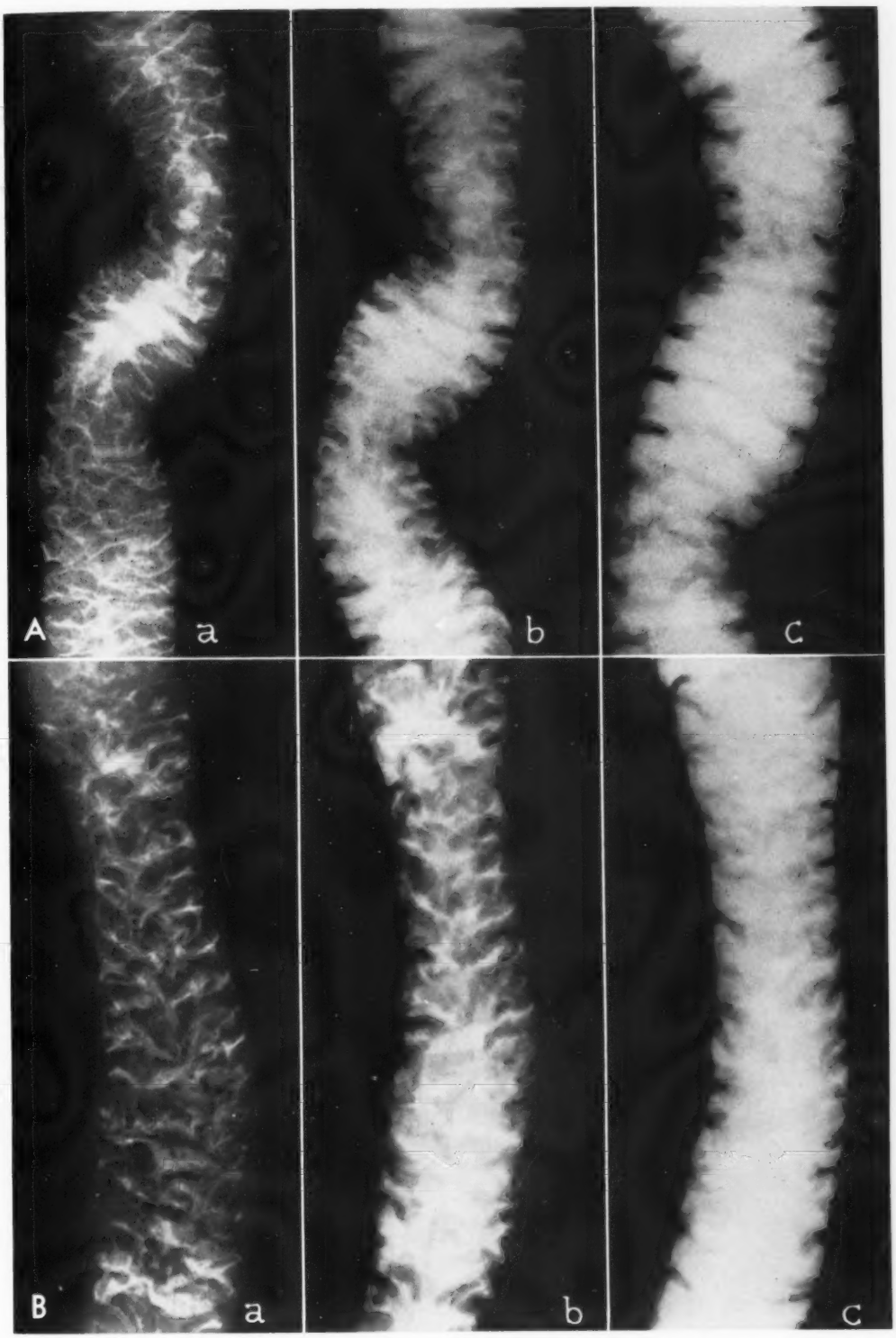

FIG. 7. (*A* and *B*) Specimen roentgenograms showing the change in the appearance of the folds associated with artificial distention. In both instances *a* represents the pattern obtained with a small amount of barium suspension outlining the tortuous primary and secondary folds. In each instance *b* and *c* represent the same loops distended more fully with the barium suspension.

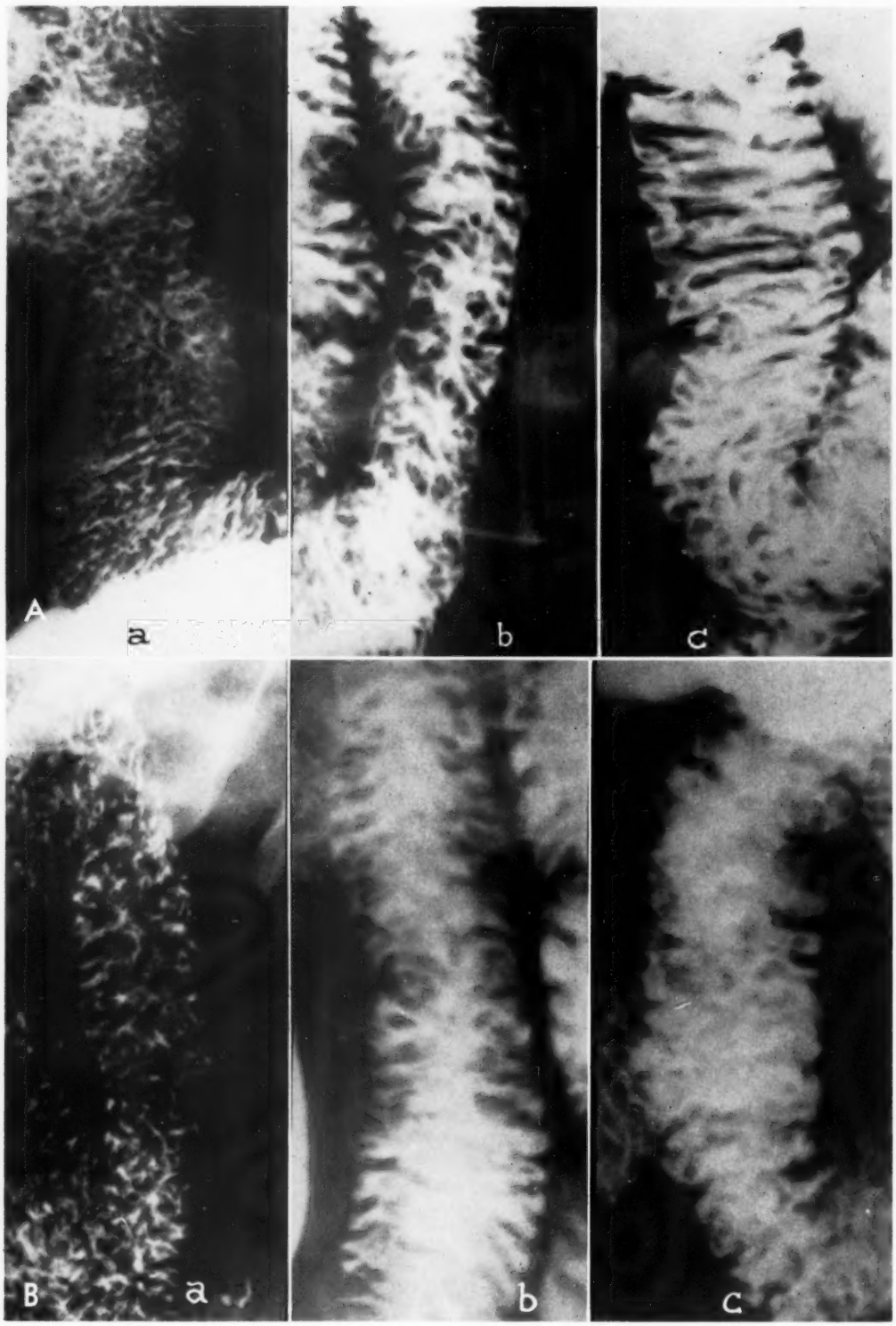

Fig. 8. Clinical roentgenograms from different individuals showing the patterns associated with contracted jejunal segments (*a*) and with varying stages of distention (*b* and *c*). These compare reasonably well with the patterns obtained from autopsy specimens.

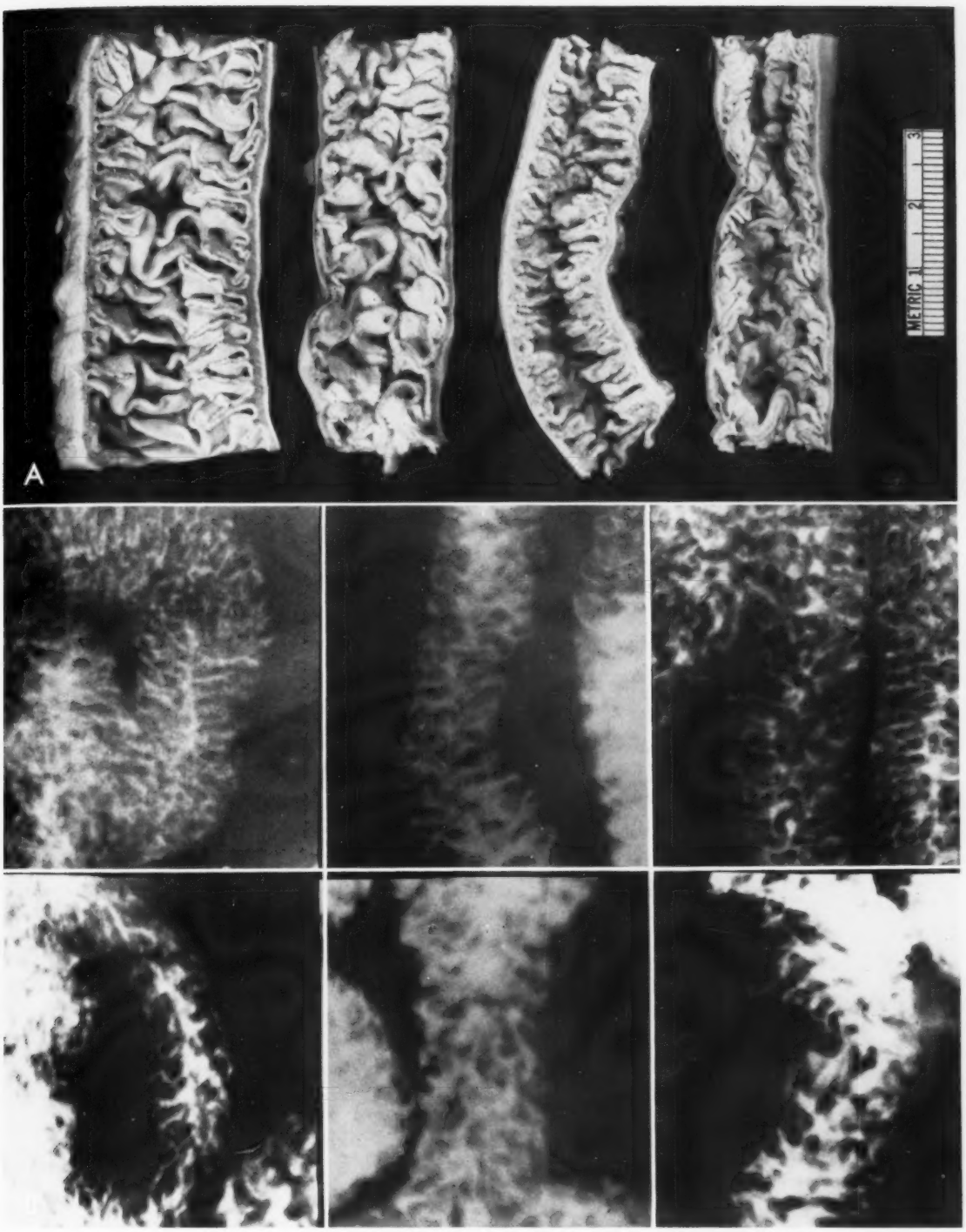

Fig. 9. (*A*) Representative contracted jejunal loops from different autopsies showing the variation in size of the individual folds from case to case. (*B*) Clinical roentgenograms of contracted jejunal segments also demonstrating considerable variation in size of the individual folds from patient to patient.

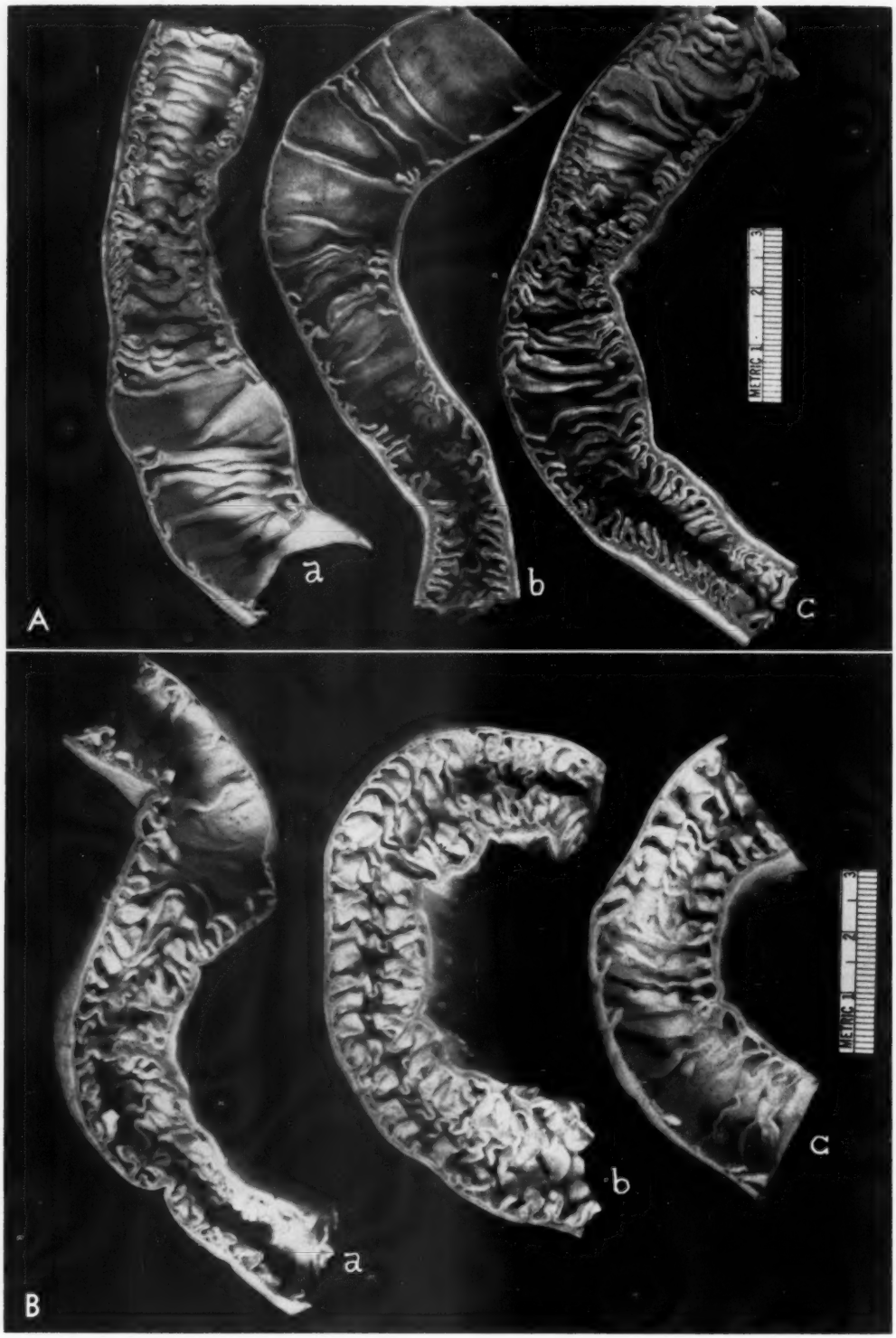

Fig. 10. (*A* and *B*) Segments of jejunum from different autopsies showing fairly abrupt changes in lumen diameters and associated mucosal patterns. At autopsy the distended areas were filled with fluid or gas, and these patterns were more common in the lower than the upper jejunum.

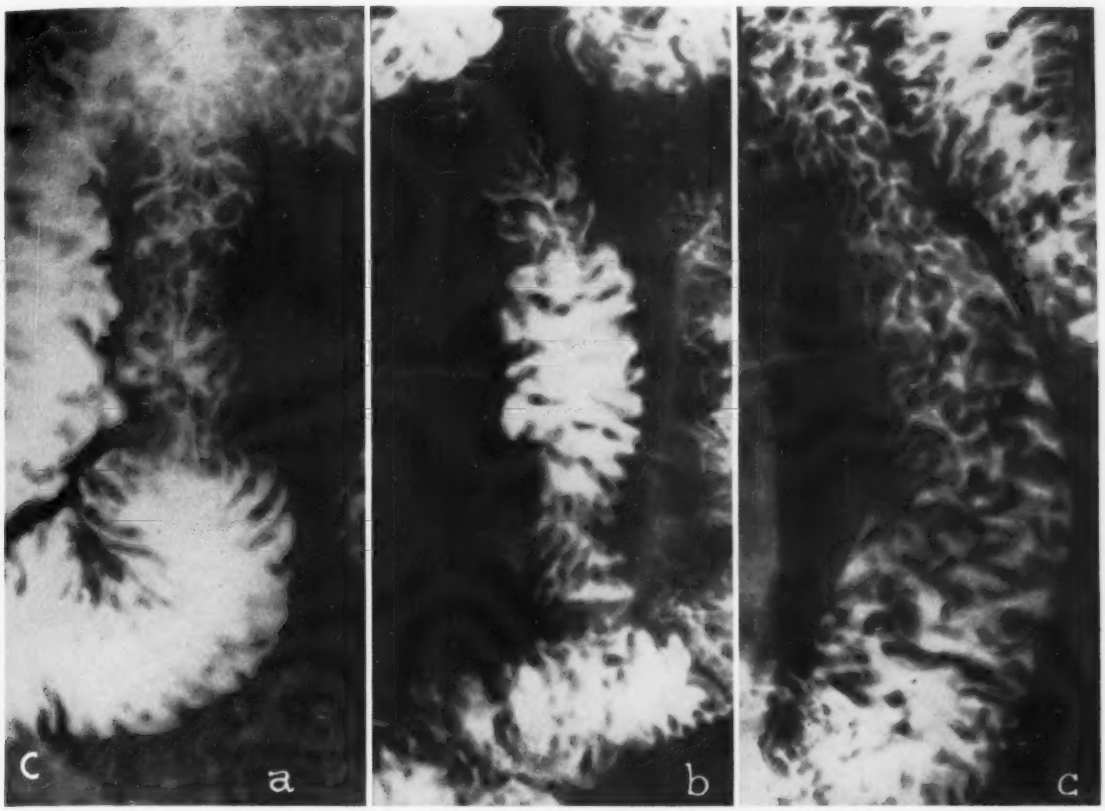

FIG. 10. (*C*) Clinical roentgenograms of jejunal loops showing somewhat similar-appearing, fairly abrupt changes in lumen diameters and mucosal patterns.

ileum, such as one sees on retrograde filling during barium enema studies.

Occasionally, however, one also finds at autopsy instances in which the terminal ileum is fixed in a state of contraction, and in Figure 12 are examples of such loops (*a*). Note the well developed mucosal folds in such instances, and the appreciable thickness of the remainder of the ileal wall.

If one takes such initially contracted ileal loops and distends them in a manner similar to that previously described for jejunal loops, one can easily reproduce the patterns seen clinically in more distended segments (Fig. 12*b* and *c*). Figure 13*A* represents a roentgenogram of an intially contracted ileal specimen which has been distended to varying degrees with a barium suspension. In Figure 13*B* the change in the mucosal pattern of an ileal loop during a barium enema study is shown, correlating the distended and contracted patterns.

In the jejunum it was noted that there was considerable variation in the size of individual mucosal folds in contracted specimens from case to case. The same is true in the ileum, as shown in Figure 14*A*, where there are different autopsy specimens of relatively contracted ileal segments. The last three specimens along the bottom row do not represent completely contracted segments, although the lumen diameter is not great. Note the longitudinal mucosal folds at *a*, which were rather uncommon in autopsy specimens. Clinical roentgenograms of contracted ileal segments are shown in Figure 14*B*.

Both clinically and at autopsy, it is common to find short ileal segments distended to varying degrees with intestinal contents. Figure 15 shows the mucosal patterns in such loops, revealing the relatively abrupt change in the folds in such areas. In Figure 16*A* are shown specimen roentgeno-

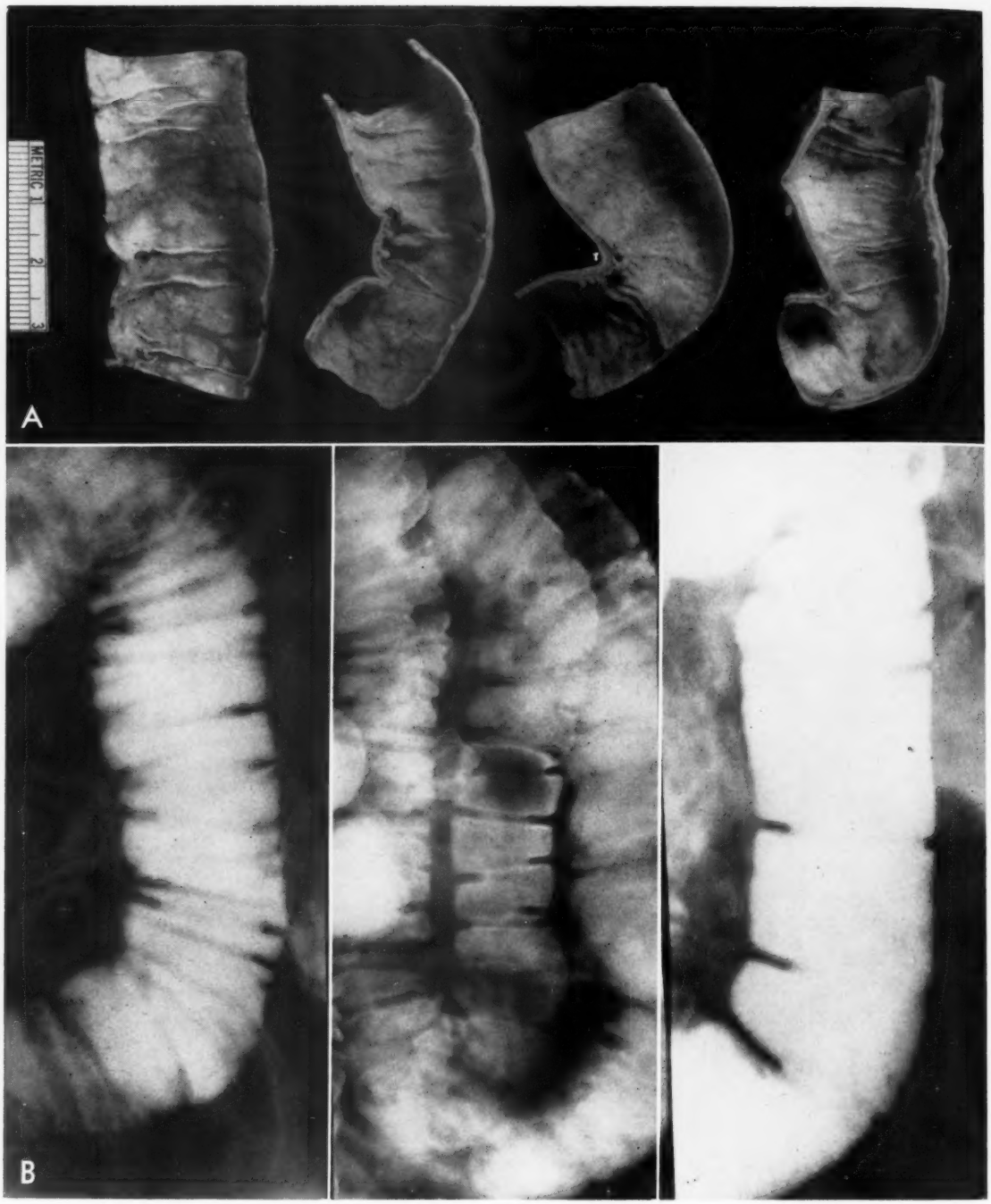

Fig. 11. (*A*) The typical pattern and appearance of the distended terminal ileum. Note the thin wall and the low, rather infrequent folds. (*B*) Clinical roentgenograms of distended terminal ileum, as seen during retrograde filling in a barium enema study. Here the folds are slightly more prominent and numerous, but the basic pattern is the same.

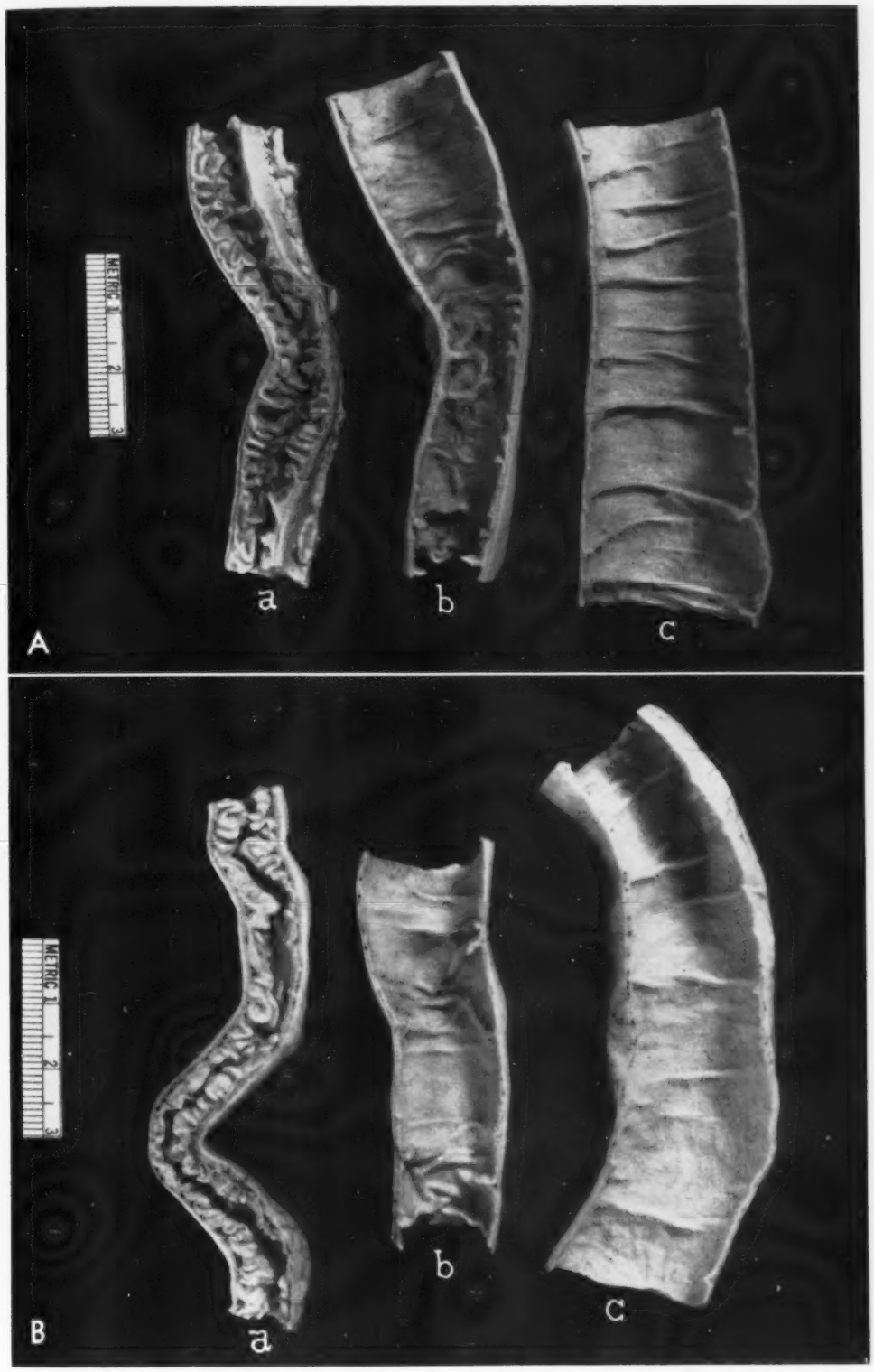

FIG. 12. (*A* and *B*) In both instances *a* represents an initially contracted ileal segment. Note the good sized mucosal folds and the considerable thickness of the wall. In *b* and *c* are shown the effects of artificial distention on the mucosal patterns of immediately adjacent loops of ileum (see Fig. 2*b*).

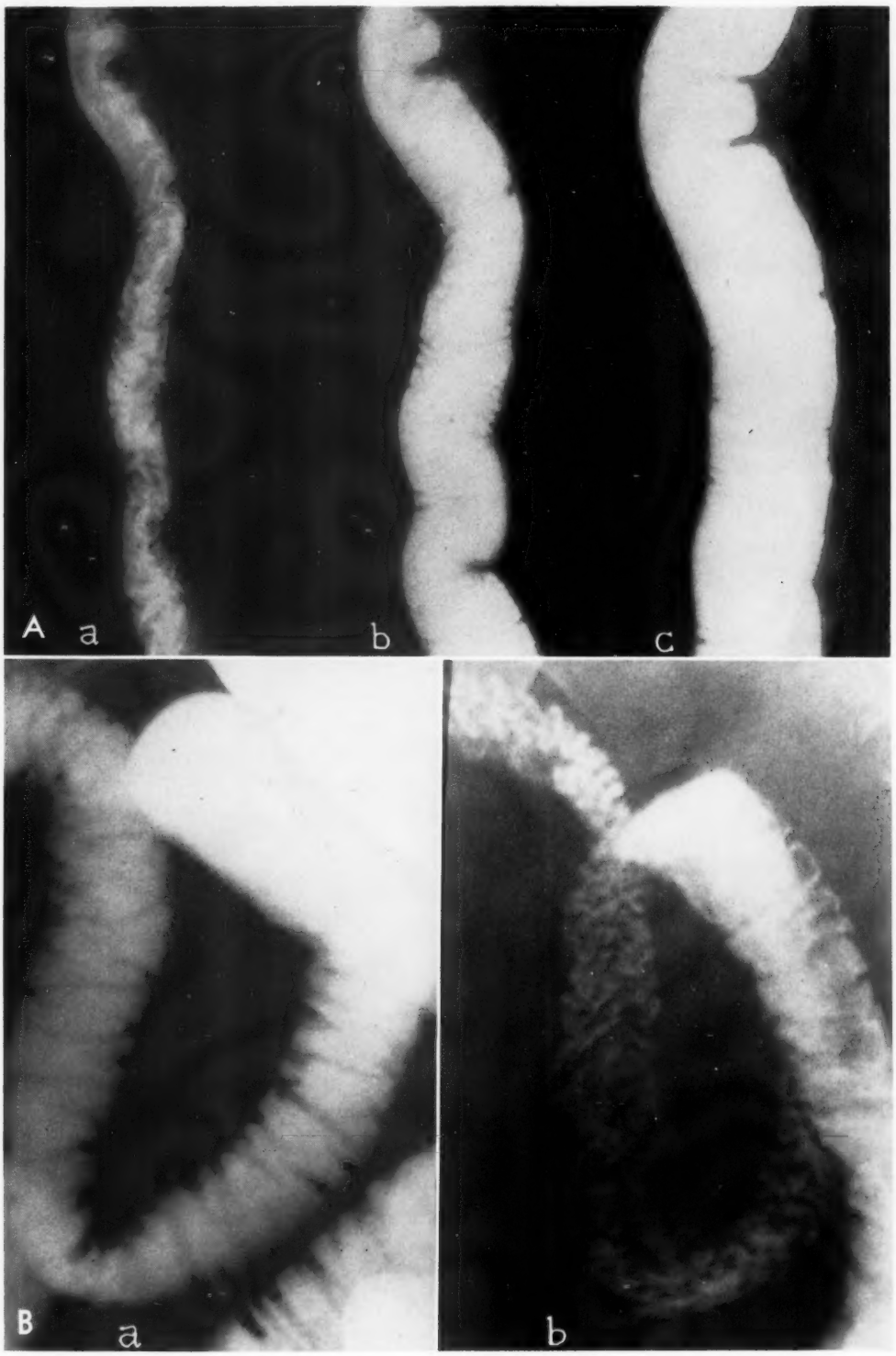

Fig. 13. (*A*) A specimen roentgenogram showing the effects of progressive distention upon the mucosal pattern of the same ileal loop. (*B*) Clinical roentgenograms of an ileal loop showing the change in the mucosal pattern from distention (*a*) to contraction (*b*).

Fig. 14. (*A*) Contracted ileal specimens from different autopsies showing considerable variation in the size of individual folds from case to case. Note the longitudinal folds at *a*. (*B*) Clinical roentgenograms from different individuals also revealing considerable variation in the size and pattern of the mucosal folds in contracted ileal segments.

Fig. 15. (*A* and *B*) It was common at autopsy to find closely adjacent ileal loops showing fairly marked variations in the degree of distention. The associated change in the mucosal patterns in such instances is well shown in these specimens from different autopsies.

FIG. 16. (*A*) Specimen roentgenograms from different autopsies revealing the change in ileal mucosal patterns in adjacent areas of contraction and distention. (*B*) Clinical roentgenograms of ileal segments revealing somewhat similar patterns.

grams of such ileal loops filled with a barium suspension, clinical studies of similar ileal loops being shown in Figure 16*B*.

DISCUSSION

In the literature one finds two widely divergent concepts as to the nature of the formation of the gross mucosal folds along the small intestine. One view is that the formation of these folds is for the most part a passive matter, related to the state of contraction of the so-called longitudinal and circular muscle groups in the outer wall of the intestine.[15] At the other extreme is the concept, advocated chiefly by Forssell, that the position and form of the mucous membrane folds are determined by active movements of the muscularis mucosae. It was his belief that marked folding of the mucous membrane could occur more easily with a simultaneous contraction of the outer muscular coat, but that for any given degree of contraction of the outer muscular layers there could be great variation in the mucous membrane relief in a segment of the intestine.[6]

It is hazardous to draw physiologic conclusions from fixed postmortem tissue, and no such attempts will be made on the basis of the present study. The findings, however, do suggest that many of the small intestinal mucosal patterns observed roentgenologically can be correlated primarily with the degree of distention of the intestine by intraluminal contents or the state of contraction of the intestine wall as a whole. One has only to study a microscopic section of the small intestinal wall to be impressed by the relatively great mass of the muscle groups in the outer layers of the intestine

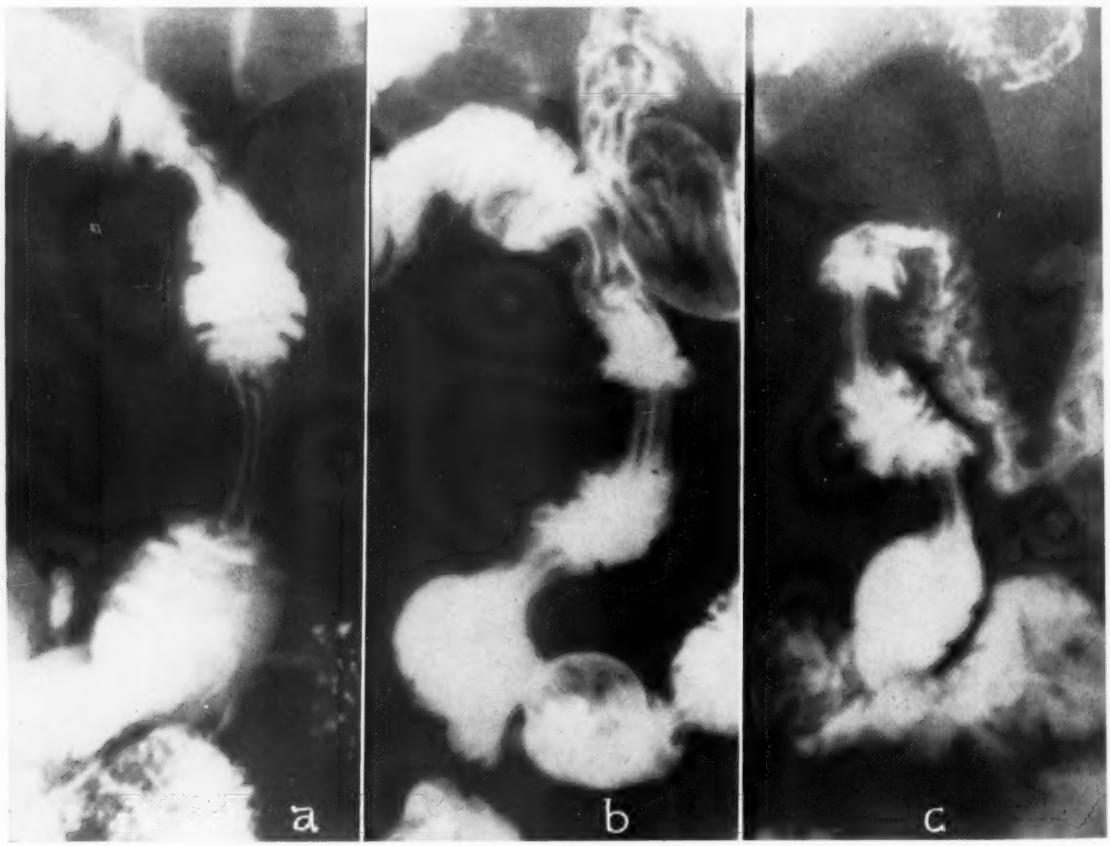

Fig. 17. Clinical roentgenograms of ileal segments showing peristaltic waves and the longitudinal folds commonly associated with such. These patterns were not seen at autopsy, nor was it possible to produce them by artificially constricting segments of intestine.

as compared with the thin and insignificant appearing muscularis mucosae.

At the same time, it was not possible at autopsy to observe or reproduce all of the small intestinal patterns detected clinically. Figure 17 represents one such pattern, showing the longitudinal distribution of the mucosal folds associated with peristaltic activity. Attempts to produce this pattern by artificially constricting autopsy specimens were not successful. Nor can one with autopsy specimens determine what possible changes may occur in the mucosal folds of a particular segment during life for any given state of contraction of the outer muscular wall. It should also be pointed out that no attempt has been made in this study to evaluate the relationship of the nature of the opaque medium and intestinal secretions to the small intestinal patterns observed clinically.[1,8,11,13]

It is hoped, however, that the current anatomic study will serve as a base line for some physiologic research into the nature, formation and permanence of the mucosal patterns which are detected clinically.

SUMMARY

An anatomic study of the gross mucosal patterns of the mesenteric small intestine, based on normal adult autopsy material, has been presented. An attempt has been made to correlate these patterns with clinical roentgenographic findings. It is hoped that the illustrations accompanying the article will be useful not only to roentgenologists but also in the teaching of normal anatomy to medical students. It is also hoped that this study will serve as a base line for some careful physiologic research on the gross mucosal folds which are of such importance to the roentgenologist.

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INTESTINAL CHANGES IN GIARDIA LAMBLIA INFESTATION*

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GIARDIA LAMBLIA, a pear-shaped, binucleate flagellate, inhabits the duodenum and jejunum of man. The incidence of infestation in institutions has been found as low as 2.5 per cent and as high as 50.6 per cent. Bøe[2] estimates the infestation of the Norwegian population at 7 per cent, and in United States troops an incidence of 5.9 per cent was found by Kofoid and Swezy.[13] Although protozoologists have viewed Giardia lamblia as a harmless commensal, physicians have repeatedly expressed conviction that it is harmful to man. Between 1940 and 1947 16 cases of giardiasis were encountered in the Columbia Presbyterian Medical Center. In 2 of these patients symptoms were ascribed to Giardia lamblia, and those 2 cases had striking abnormalities of the small intestine as demonstrated by roentgen examination. Of the remaining cases, 5 had gastrointestinal examinations and no abnormalities were found. The purpose of this paper is to report the 2 cases of giardiasis showing the small intestinal abnormalities.

LITERATURE

Since the discovery of Giardia lamblia by Leeuwenhoek in 1681 and their description by Lambl, human infestation has been the subject of many reports. The early papers[1,14,15,17,18,21] reported cases of giardiasis with a variety of symptoms which were ameliorated by eliminating the parasite. The symptoms included diarrhea, constipation, abdominal swelling, failure to gain or grow, and vague abdominal pains. Because Giardia was found in '*B*' bile upon duodenal drainage,[6,11] it was thought that the parasite invaded the biliary tract and could cause cholecystitis. Most of the evidence to the effect that Giardia could cause trouble was presumptive and not very critically appraised. Boeck[3] found it unacceptable.

Three patients harboring Giardia lamblia and coming to postmortem examination have been reported. The first, by Fairise and Jannin,[7] was a thirty-nine year old Indo-Chinese miner who had severe diarrhea for a period of ten months followed by a peritoneal abscess which was drained with improvement. However, five months later he developed intestinal obstruction and died. Extensive ulcerations were found in the lower small intestine and colon, and a cauliflower-like mass was found in the cecum. Both motile and encysted forms of Giardia were demonstrated in areas of ulceration at all levels in the wall of the intestine. They were found even in the subserosal tissues associated with miliary abscesses. The ileum showed atrophy of glands and inflammatory changes in the wall with micro-abscesses in the submucosa. The upper small intestine received little comment in the description and one must suppose that it was normal. These writers inferred that Giardia actively invades the wall of the intestine.

The second case was reported by Gaivoronsky[9] who described ulcerations in the lower small intestine of a cachectic man who had suffered from chronic enteritis. Giardia was found in the small intestine.

The third case was recently reported by McGrath, O'Farrell and Boland.[16] Their patient had attacks of diarrhea all his life. At forty, his diarrhea became continuous. His stools were pale and voluminous. He lost weight and strength. Giardiasis was demonstrated by duodenal drainage. The fat content of his stools was abnor-

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mally high during his last admission. Seventy-seven and six tenths per cent of the fat was split and only 12.3 per cent neutral. Roentgen examination of the small intestine showed marked segmentation of the barium with positive "string" and "moulage" signs. At autopsy, the walls of the duodenum and jejunum were thin, the valves of Kerkring practically absent; the villi and crypts were denuded of epithelium with infiltration of the villi by round cells. In the ileum there were many ulcerations with marked narrowing of the lumen just proximal to the ileocecal valve. The wall of the ileum was greatly thickened and rubbery. Mesenteric lymph nodes were enlarged with hyperplasia and edema, microscopically. Although various staining methods were used, Giardia could not be demonstrated, either attached to the epithelial cells or deeper in the walls of the intestine.

These 3 cases constitute the available and not convincing histologic evidence favoring the pathogenicity of Giardia lamblia. The lesions in Fairise and Jannin's patient were in the ileum and colon, whereas, the natural habitat of Giardia lamblia is the duodenum and jejunum. Boeck[3] believes that his patient had chronic ulcerative colitis with a secondary neoplasm in the cecum and that Giardia was a contaminant in areas of ulceration.

The case history of McGrath, O'Farrell and Boland's patient reads like the description of regional enteritis. What part, if any, Giardia lamblia may have played is not established. The infestation may have been coincidental.

By their experimental work, Fantham and Porter[8] were able to infest mice and kittens with Giardia lamblia in strained feces from cases of dysentery. Six of 8 kittens and six of 8 mice developed diarrhea, failed to gain weight or lost weight. Several of the animals died. The infested animals showed Giardia in their stools. The animals which remained well had no Giardia and no pathologic changes were observed at autopsy. The other animals showed shedding of the mucous membrane with inflammatory changes. Giardia was found attached to epithelial cells. Deschiens[5] confirmed these findings using mice. Simon[20] could not infest rats. Fantham and Porter interpreted their findings as evidence of the pathogenicity of Giardia to man and believe that cats and mice might serve as reservoirs for the organisms.

Giardia lamblia was thus clearly shown to be pathogenic to the artificial hosts used. This unfortunately does not constitute proof that the natural host, man, is similarly affected.

Recent clinical observations indicate that vitamin A absorption is markedly decreased in children with giardiasis. Katsampes, McCoord and Phillips[12] showed that after elimination of the parasites the absorption of vitamin A improved greatly or returned to normal. It is of interest that the patient of O'Donovan, McGrath and Boland,[19] and a patient reported by Chaudhuri[4] showed an increase in the fat content of their stools.

Chaudhuri's patient was a forty-eight year old Hindu woman with diarrhea, flatulence and pale bulky stools. The roentgen examination of the stomach and small intestine showed no abnormality and it was stated that no dilatation, segmentation or deficiency pattern was found. She was given acid pepsin and injections of crude liver extract, with only slight improvement. Crinodora, an atabrine substitute was added, and the diarrhea stopped; the abdominal pain disappeared; the stools became normal in color and were free of cysts for six successive days.

In summary, one may say that clear-cut evidence of the pathogenicity of Giardia lamblia in humans has not been presented. It may be that the harmful effects of giardiasis are the result of disturbances of intestinal function as is suggested in the cases reported below.

REPORT OF CASES

CASE 1. A sixty-four year old business woman (Presbyterian Hospital No. 857424) was admitted February 4, 1947, complaining of inter-

mittent abdominal swelling of many years' duration. She had traveled extensively in Europe and the West Indies. She was subject to frequent upper respiratory infections followed by prolonged cough. She suffered from chronic constipation and customarily took three compound cathartic pills each night and milk of magnesia once a week.

In 1922, while traveling in Europe, she first noted abdominal swelling. It came suddenly, lasted a day or two, then subsided. At intervals of one to two weeks swelling recurred and, with it, slight periorbital swelling in the mornings and mild ankle edema in the evenings. Subsequent attacks were similar with some fatigability in later years. For a while the diagnosis of renal tuberculosis was considered but was never confirmed. Between 1923 and 1945 she had only slight swelling when she became excessively tired. In 1945 attacks of swelling became severe and persisted until admission. In 1946 she was hospitalized elsewhere and abdominal paracentesis during an attack yielded no fluid. After September, 1946, the swelling recurred very frequently with some residual swelling at all times. She gained eighteen pounds in weight.

Physical examination revealed a well developed, well nourished woman in no distress. The positive findings were mild hypertrophy of the lymphoid tissue in the pharynx, slight postnasal drip and symmetric moderate enlargement of the abdomen with some striae. No fluid wave or shifting dullness was demonstrable.

Various laboratory examinations disclosed nothing abnormal except for slight elevation of the blood cholesterol. Three stools examined on successive days were negative for occult blood but showed numerous cysts of Giardia lamblia.

Roentgen examinations of the chest and colon revealed no abnormalities. The gastrointestinal examination showed marked coarsening of the mucosal folds of the stomach and duodenum. The transit time of a barium-saline preparation was long; barium did not reach the cecum until after nine hours despite food stimulation. Marked coarsening of the folds in the jejunum was associated with segmentation, hypertonicity of loops and flocculation of the barium. In the ileum, the barium was mixed with an excess of fluid and the mucosal folds were not demonstrated. The changes were interpreted as evidence of a marked physiologic disturbance (Fig. 1).

A roentgenogram of the abdomen was made during a period of marked abdominal distention and showed an insignificant amount of gas in the colon. This swelling of the abdomen was interpreted by her physician as a neurotic manifestation not related to the giardial infestation.

Her stay in the hospital was uneventful except for continued abdominal swelling. On February 15, 1947, treparsol, a French arsenical preparation, was started, one tablet the first and second days, and two tablets the third and fourth days. The patient was discharged February 19, 1947.

Stools examined on March 3, April 9 and June 19, 1947, showed no Giardia. On this last date the patient was feeling perfectly well and strong and a re-examination of the small intestine showed considerable improvement in transit time though the barium did not reach the cecum until four hours. There was a marked improvement in the mucosal pattern with no coarsening of the folds or segmentation of the barium column (Fig. 1 and 2).

Case II. A thirty-nine year old business man (Presbyterian Hospital No. 817486) was admitted February 8, 1946, complaining of intermittent diarrhea of twelve years' duration. He had traveled extensively in the United States and had spent one year in South America. In 1934 he began passing eight to twelve bulky, foamy, foul-smelling stools daily. Bouts of such diarrhea would last about two weeks, disappear for a few days, and then recur. In a few months he had lost ten pounds and was easily fatigued. He experienced some periods of relief, one after a course of sulfanilamide therapy and another, lasting four months, after taking arsphenamine for Vincent's angina. The latter response prompted two more courses of arsphenamine therapy which had to be stopped because of enlargement of the liver. In 1945 his weight had fallen to 113 pounds and he was having severe intermittent headaches as well as marked diarrhea. He discovered that candy relieved his headaches, so ate much of it. Hospitalized in Chicago, July 1945, hypotension was discovered and also cysts of Giardia lamblia in his stools. Roentgenograms of the small intestine were described as revealing some widening of jejunal loops. He had achlorhydria. Various chemical examinations of the blood revealed nothing abnormal. After a course of treatment with atabrine, he gained twelve pounds, had less diarrhea and felt stronger.

Physical examination after admission to the

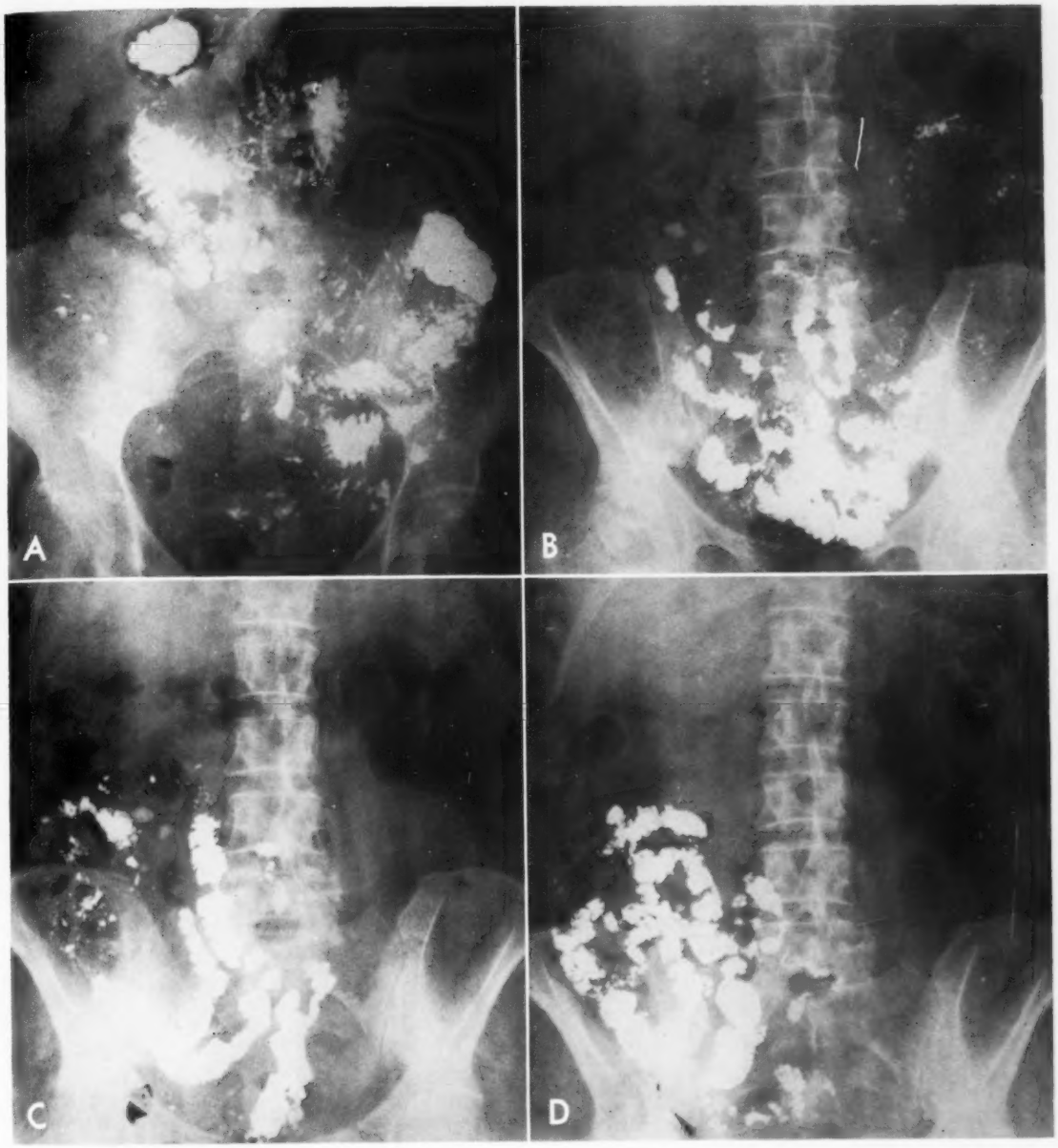

FIG. 1. Giardiasis. Case 1 before treatment. (*A*) One hour film showing marked segmentation in the upper jejunum. The mucosal pattern is coarsened and irregular. Some widening of the lumen is present. (*B*) At three hours hypomotility is apparent, with hypertonicity, segmentation and mucosal coarsening. (*C*) Five hour film; the barium has not entered the cecum despite milk stimulation. (*D*) The six hour film, after a meal, shows a granular character of the barium shadows which suggests mixing of barium with residual fluid.

Presbyterian Hospital revealed emaciation and hypotension, blood pressure 88/48. Laboratory studies, including liver and pancreatic function tests, gave positive results as follows: a basal metabolic rate of plus 28 per cent, serum proteins of 4.9 gm. (albumin 4.0 gm., globulin 0.9 gm.), many giardial cysts in the stools and numerous vegetative forms in fluid from the duodenum. Roentgen examination of the paranasal sinuses disclosed marked clouding of the maxillary antra. An upper gastrointestinal examination demonstrated marked abnormalities of the small intestine consisting of prolonged transit time, marked segmentation with a moderate

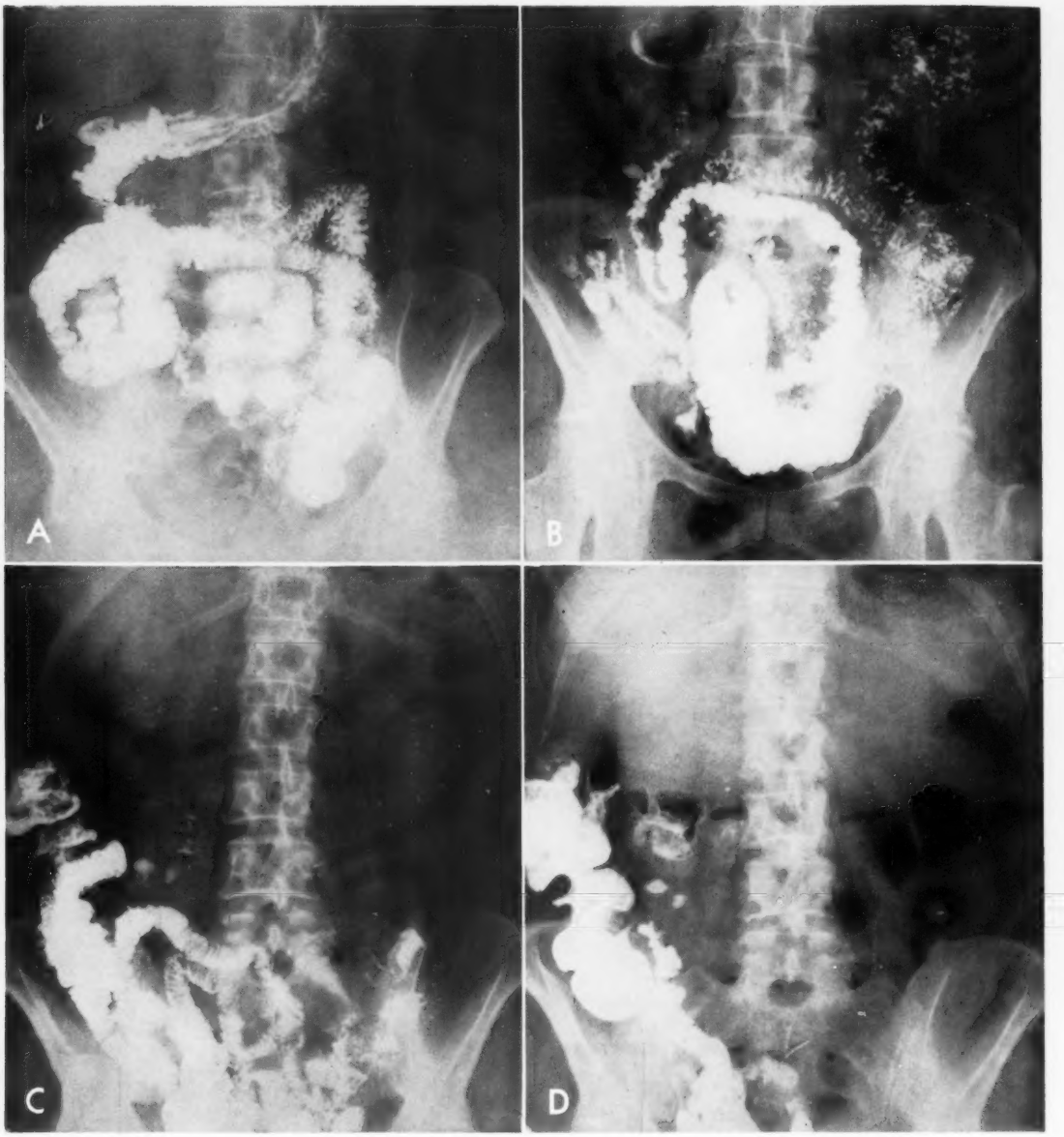

Fig. 2. Giardiasis. Case 1 after treatment. (*A*) The one hour film shows no segmentation and the mucosal pattern, caliber of the lumen and motility are within normal limits. (*B*) At three hours the barium column is continuous in the middle portion of the small intestine. (*C*) At four hours the cecum and ascending colon are beginning to fill. (*D*) The five hour film shows normal terminal ileum. The smooth and rounded contour of the cecum is ascribed to prolonged use of cathartics.

degree of dilatation of loops and coarsening of mucosal folds, most pronounced in the middle loops of small intestine (Fig. 3).

He was given pencillin nose spray, vitamin B-complex, vitamin C and atabrine 0.1 gm. twice daily and discharged on February 20, 1946. He could not take the atabrine faithfully because of nausea but gained six pounds although his diarrhea continued.

On June 4, 1946, he was re-admitted. His hypotension was little changed and he had fissuring in the nasolabial folds. He had no anemia. Numerous Giardia were found in the stools and by duodenal drainage. He was given chloroquin,

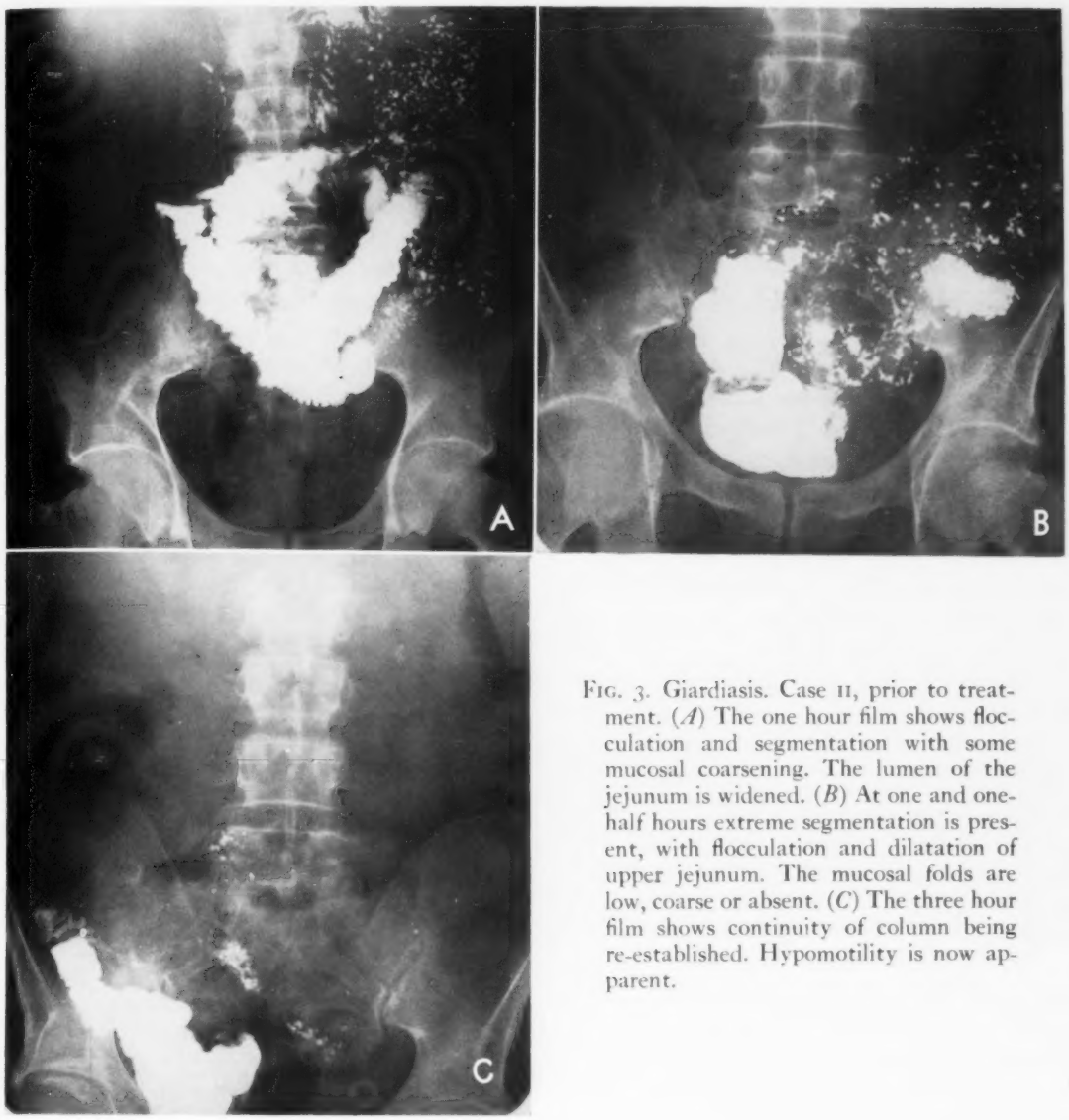

Fig. 3. Giardiasis. Case 11, prior to treatment. (*A*) The one hour film shows flocculation and segmentation with some mucosal coarsening. The lumen of the jejunum is widened. (*B*) At one and one-half hours extreme segmentation is present, with flocculation and dilatation of upper jejunum. The mucosal folds are low, coarse or absent. (*C*) The three hour film shows continuity of column being re-established. Hypomotility is now apparent.

one tablet per day for two days and then two tablets daily. On June 19, a papilloma was excised from the margin of his anus and soon thereafter he was discharged from the hospital.

He has been followed one year with visits at one to two month intervals. His weight slowly rose from about 120 to 142½ pounds. He took the chloroquin at intervals and found that soon after stopping it his diarrhea returned. Stool examinations showed absence of Giardia for periods of time corresponding to relief of diarrhea, but when diarrhea returned so did the Giardia. Various schedules of administering the drug were used, but if the chloroquin was discontinued for long, diarrhea would recur. He gained strength and weight and was able to return to full business activity. He also took vitamin B-complex and crude liver extract.

Comment. After discharge from the hospital the patient took vitamin B-complex and liver extract continuously and they may have aided in the response he had, but it was the antigiardial drug that controlled his diarrhea. The abnormalities of his small intestine, showed by roentgen

examination, are those commonly seen with marked nutritional disorders such as sprue. Unfortunately, re-examination of his small intestine after treatment was not done.

DISCUSSION

Since only 2 of 16 patients harboring Giardia lamblia were found to have symptoms ascribable to the Giardia, it is probable that, in many instances, the parasite is present without harm to the host. A commensal relationship must exist in such instances, but in the cases described above the relief of symptoms and improvement in general health following antigiardial therapy were too pronounced to be considered coincidental; moreover, similar effects of Giardia are reported in the literature. Giardia lamblia can cause symptoms but just how is not clear. The histologic evidence for pathogenicity is inconclusive, for in the cases reported by Fairise and Jannin and by McGrath *et al.*, the pathologic changes were in unexpected places and the nature of the changes leads one to suspect other coexisting diseases. The significance of the experimental infestations produced by Fantham and Porter is not clear.

That a functional disturbance occurs is clearly shown by the reduced vitamin A absorption described by Katsampes, McCoord and Phillips. In the 2 cases reported here, evidence of marked motor dysfunction was shown by roentgen examination, and in the case simulating sprue there must have been faulty absorption. One might justifiably raise the question of cause and effect in the production of the sprue-like syndrome. The disturbance of absorption caused by Giardia may have resulted in the development of vitamin deficiencies as well as deficiencies of other essential food elements with consequent changes in intestinal pattern.

The abnormalities of the small intestine shown by roentgen examination are not specific for giardiasis, but in the first case the coarsening of the mucosal folds and the segmentation were as marked if not more marked in the upper jejunum as in the mid-small intestinal region. This is not the usual finding in simple nutritional disorders. In them the middle of the small intestine shows the greatest deviation from normal.[10] In the second case the changes are those of an advanced nutritional disorder and have no peculiarities that might be ascribed directly to the Giardia. In animals the organisms are known to attach themselves to epithelial cells in such numbers as to blanket the surface of the mucous membrane. Thus they might disturb absorption and possibly cause derangements of the motor activities of the villi. It is even possible that in severe, symptomatic giardial infestation, histologically demonstrable changes in the epithelial cells may occur, but to date acceptable evidence is lacking.

SUMMARY

1. Two cases of Giardia lamblia infestation are presented in which changes in the intestinal pattern similar to those associated with nutritional disorders were demonstrated by roentgen examination. Following elimination of the parasites in one case the patient's symptoms disappeared and the intestinal pattern returned to normal. In the other case the parasites could not be permanently eradicated but when he was receiving large doses of antigiardial drugs he was symptomatically well. It is not clear whether this abnormal motor function was caused directly by the parasites or whether it was due to a nutritional disorder caused by them.

2. The literature has been reviewed to show that the evidence for pathogenicity of Giardia lamblia consists of improvement in symptoms after elimination of the Giardia, questionably interpreted postmortem findings in 2 patients with giardiasis and the demonstration of reduced vitamin A absorption in the presence of giardiasis in children.

3. More careful studies of absorption by the intestinal mucous membrane are needed in cases of giardiasis.

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I wish to thank Dr. Dana W. Atchley for granting permission to publish the material pertaining to his private patients and for his many helpful suggestions and criticisms of the manuscript. To Dr. Ross Golden I also owe a great debt of gratitude for his interest and many constructive criticisms.

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PNEUMATOSIS CYSTOIDES INTESTINALIS*

REPORT OF A CASE

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IN THE past two decades, case reports of pneumatosis cystoides intestinalis have appeared rather increasingly,[3,5,10–15,18,19,22] although there are still relatively few cases reported in the American literature since Finney[7] reported the first case in this country in 1908. In a critical review of this subject in 1952, Koss[11] was able to collect 213 cases of abdominal gas cysts reported in both European and American literature. Because most of these cases were discovered either at operation or postmortem examination, Graberger[9] and Berglund[2] emphasized the need for preoperative roentgen diagnosis. In most of these cases, Berglund stated, surgeons thought that they were dealing with a malignant process, and therefore performed large resections.

It is our purpose to re-emphasize the need for an accurate preoperative diagnosis of this entity from both roentgenologic and pathologic viewpoints by presenting a case that was not recognized before surgery.

REPORT OF A CASE

T. W., a sixty-three year old white male, had been admitted to Barnes Hospital on ten previous occasions for treatment of cardiovascular disease. He was admitted for the eleventh time on December 11, 1954, with the chief complaint of flatulence and diarrhea of over one year's duration.

For about two years he had had increasing constipation with lower abdominal distention and vague abdominal pains, relieved by passage of flatus and frequent small, mucus-containing stools.

The pertinent physical findings were those visualized at proctoscopy. In the upper rectum and lower sigmoid colon were seen multiple sessile and pedunculated polypoid lesions that measured from 1 to 3 cm. in diameter. The mucosa was intact over these without ulceration although small cystic areas were seen on the surface of the larger polypoid lesions. There was no constricting lesion seen and the lower rectum appeared normal. A biopsy specimen removed was interpreted as an adenomatous polyp (Fig. 1). However, upon review of the slides, the diagnosis of pneumatosis could have been made as evidenced by the presence of submucosal cysts among a rather loose, congested stroma and overlying intact mucosa.

A barium enema examination was performed with canalization to the splenic flexure (Fig. 2, *A* and *B*, and 3). A partial obstruction was observed in the sigmoid colon interpreted as being due to multiple polyposis with a segmental area of narrowing suggestive of carcinoma. Air contrast enema study was performed and there was obstruction in the distal sigmoid colon. Multiple rounded filling defects were again noted and interpreted as polyps. The point of obstruction demonstrated over-

FIG. 1. Photomicrograph of biopsy from sigmoid colon showing a submucosal cyst lined partly by flattened cells and adjacent rather loose, congested stroma. This was erroneously interpreted as an adenomatous polyp. (Low power.) W. U. Neg. 55-586A.

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This paper was prepared with the help of Dr. Lauren V. Ackerman.

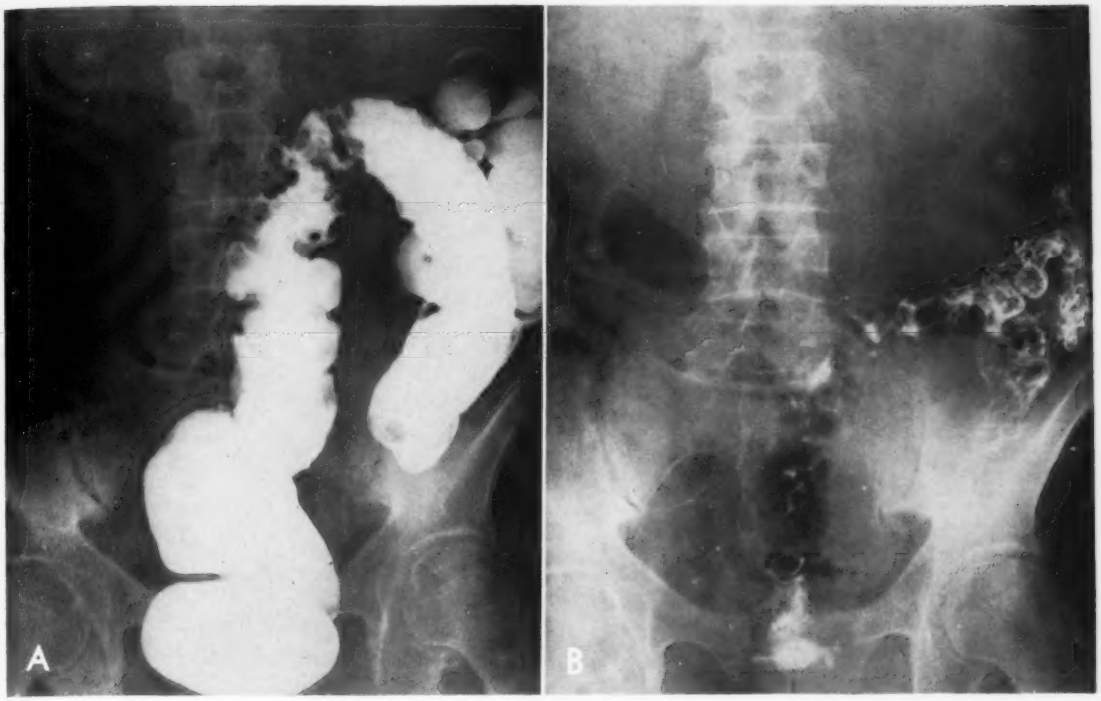

Fig. 2. (*A*) Barium enema film demonstrating radiolucencies misinterpreted as polyps. The broad base and extension into the bowel wall are characteristic. (*B*) Evacuation film demonstrating extent of cysts in the upper rectum and sigmoid colon.

hanging margins thought to be consistent with a constricting carcinomatous lesion (Fig. 4).

Routine laboratory examinations were essentially negative. The hemoglobin was 12.8 grams. Stool guaiac reaction was negative on three occasions.

At exploratory laparotomy, the surgeon still thought that the lesion was of a malignant nature and performed a left colectomy. There were no abnormal findings in the abdominal cavity other than those in the resected segment of the large bowel.

Fig. 3. Enlargement of the area, interpreted as carcinoma, demonstrates narrowing of the lumen due to gas cysts.

The patient had an uneventful postoperative course, and follow-up proctoscopic examination and air contrast enema study one month after discharge from the hospital were negative.

Pathological Examination. The surgical specimen which consisted of 28.5 cm. of the left colon was recognized at gross examination as typical of pneumatosis cystoides intestinalis.

On exposure of the mucosal surface of the involved bowel, there were seen in the distal third about 80 pale pink, grape-clusterlike, polypoid masses with smooth surfaces and somewhat doughy consistency (Fig. 5 and 6). These were sessile and closely aggregated, tending to form confluent lesions in many places. There was no evidence of necrosis, ulceration or fixation of the bowel wall. The remainder of the colon was normal.

Sections through the involved sigmoid colon showed numerous well-defined, empty cystic lesions with smooth and glistening internal sur-

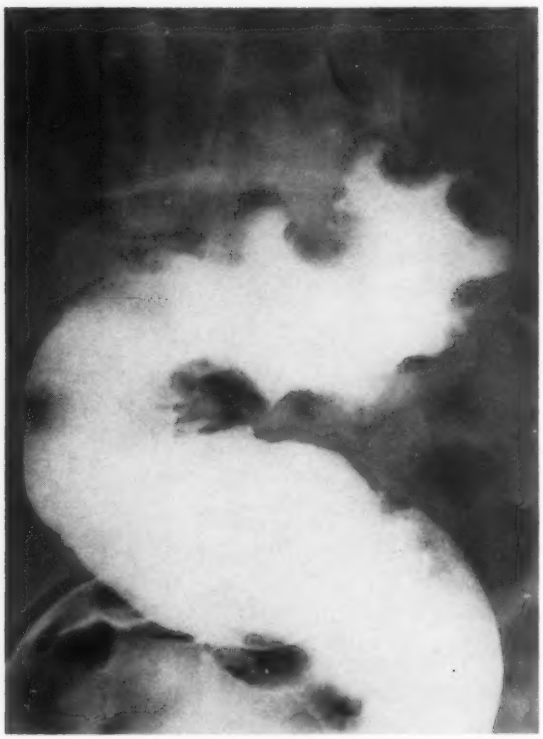

Fig. 4. Complete obstruction to retrograde flow caused by gas cysts.

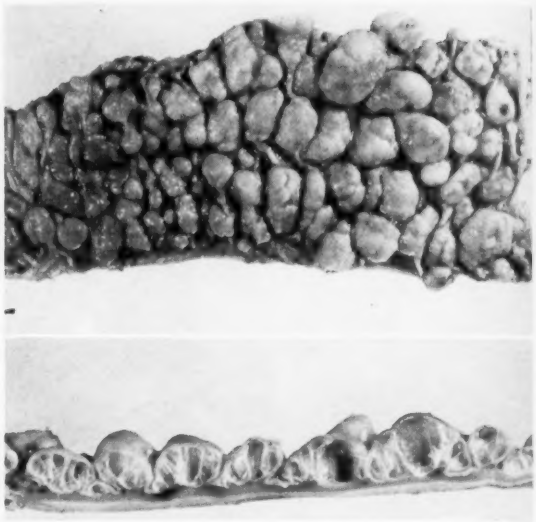

Fig. 5. Photograph of gross specimen of sigmoid colon from left colectomy showing polypoid, grape-clusterlike masses formed by submucosal gas cysts. Cut section (below) reveals honeycombed, cystic spaces localized to the submucosa.

faces, the largest of which measured 3.5 cm. These were located in the submucosa and sharply limited beneath by the muscularis propria. The lesions were frequently multicystic and thin-walled but did not appear to communicate with each other. On puncturing these cysts under water, gas bubbles were liberated.

A gas analysis performed two weeks after formalin-fixation of the specimen showed 12.2 per cent oxygen, .046 per cent carbon dioxide, and no sulfide content.

Microscopically, the sections of the sigmoid

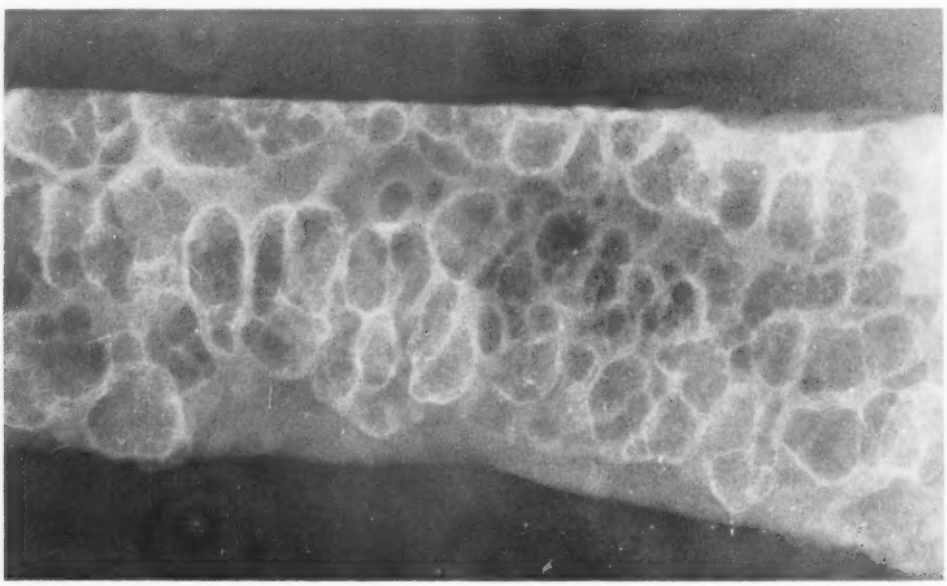

Fig. 6. Roentgenogram of formalin-fixed specimen showing thin-walled, discrete, and gas-filled cysts.

Fig. 7. Photomicrograph of routine sections from sigmoid colon showing a submucosal cyst, characteristic lining cells, and granulomatous changes in the stroma. (Low power.) W. U. Neg. 55-587A.

colon showed cystic spaces of varied size within the submucosa lined by flattened to cuboidal cells separated from each other in places by thin and rather delicate fibrous septa. The surrounding connective tissue stroma showed a mild predominantly lymphocytic infiltration with occasional giant cell formation and vascular dilatation (Fig. 7). Multinucleated giant cells lining the cystic spaces were also seen, and in other areas a granulomatous type of reaction was noted in the submucosal connective tissue stroma. The muscularis and serosa were not remarkable.

DISCUSSION

The symptoms of diarrhea, flatulence, and vague abdominal pains resemble the symptomatology of previously reported cases.[1,5,10,11,12,15] However, there are no pathognomonic clinical findings associated with this process. In general, the major manifestations are those of the underlying disease.

The roentgen findings as disclosed in the examination of this patient are characteristic. In plain scout roentgenograms gas filled cysts show radiolucent areas localized to the bowel wall which must be differentiated from gas within the lumen of the bowel. After the introduction of opaque contrast medium, the radiolucencies can be more easily recognized. In such films the cysts occupy the margin of the contrast medium and are visualized through the opaque column. The criteria for differentiation from polyps or other intraluminal tumors may be summarized as follows: (1) There is relative increased radiolucency as contrasted to the soft tissue density of polyp or other tumor. (2) There is change in size of gas cysts with flattening of their base when the bowel is distended. The gas within the cyst is compressible and allows change in shape of the masses in a manner not characteristic of polyps. (3) Because of their localization within the bowel wall, a portion of the lucent defect extends beyond the contour of the barium column. (4) The base of the filling defect is broad as compared with that of the polyp and the lesions resemble intramural tumors found elsewhere in the gastrointestinal tract. There is smooth elevation of the mucosa rather than the irregular outlines seen with tumors and polyps. (5) In the area of an obstruction the overhanging edges are relatively lucent as contrasted with the soft tissue density of tumor.

Although the etiology and pathogenesis of pneumatosis cystoides intestinalis is not as yet firmly established, the mechanical[17] and chemical deficiency theories expressed by Joest and also by Masson as cited by Koss[11] are generally accepted at present as best explaining the origin and formation of gas cysts. Both agree that the gas occupies and distends lymphatic spaces. The mechanical theory fails to explain those cases not associated with an ulcerative process, but appears to be substantiated by the chemical deficiency theory which postulates that because of alteration of

the hydrogen ion concentration of the intestinal content, gas is produced in the lymphatics or absorbed into them as a result of increased permeability of the mucosa. The cysts may spontaneously disappear.

Thirty-three of the 213 cases reviewed by Koss[11] were considered to be primary, and there were only 9 cases localized to the large bowel. According to Villaume,[24] cysts localized to the sigmoid colon are very uncommon. The majority of the cases were secondary to some other associated disease process, *e.g.*, gastric or duodenal ulcers, enteritis, peritonitis, recent intestinal operations, gastroptosis, intestinal parasitism, etc. In our case, there is no evidence that the lesion is secondary to any of these variously considered etiologic factors and most probably represents a primary pneumatosis cystoides intestinalis. Furthermore, submucosal cysts which are considered less common were the only ones encountered in our case and were not associated with serosal cysts as usually noted. The cases that underwent resection are listed in Table 1.

It is evident from the clinical and roentgen findings that our patient had a partial intestinal obstruction caused by the submucosal gas cysts. The incorrect interpretation of the roentgen and biopsy findings

Table 1

RESECTED CASES OF PNEUMATOSIS INTESTINALIS

Author	Date	Sex	Age	Bowel Involved	Location of Cyst	Clinical Diagnosis	Result
Urchino	1912	M	not stated	ileum, 10 cm.	subserosal	chronic appendicitis	recovered
Neugebauer	1914	M	21	end of ileum, cecum, ascending colon, and hepatic flexture	subserosal	ileocecal tumor	recovered
Demmer	1914	M	42	ileum and transverse colon	subserosal, muscular, and submucosal	pyloric and intestinal stenosis	recovered
Kuder	1915	M	46	small intestine	not stated	pyloric stenosis from ulcer	recovered
Kuder	1915	F	61	small intestine, 15 cm.	submucosal	gastric ulcers	recovered
Warstat	1917	M	42	intestine, site not stated, 60 cm.	subserosal	pyloric stenosis	recovered
Lafourcade	1919	M	not stated	small intestine, 50 cm.	submucosal	pyloric stenosis due to ulcer	recovered
Nitch and Shattock	1919	F	40	cecum, ascending colon, and proximal transverse colon	subserosal?	intussusception	recovered
Hey	1920	M	41	small intestine, 45 cm.	subserosal	pyloric obstruction	recovered
Schulte	1922	M	36	lower ileum 20 cm.	submucosal and muscular	ileus	died from pneumonia
Bubis and Swanbeck	1922	M	33	cecum and ascending colon	submucosal, muscular and subserosal	intussusception, tumor of cecum or appendix	recovered
Mills	1925	M	43	lower ileum, 6 ft. and hepatic flexure	subserosal?	severe chronic abdominal pain	recovered
Englund and Wahlgren	1935	F	39	lower ileum	subserosal	gastric ulcer with pyloric stenosis	recovered
Parsons and Parsons	1948	M	37	upper jejunum and ileum, 23 cm. and 17 cm. segments	subserosal, subserosal and submucosal	intestinal obstruction	recovered but recurred after 2.5 years; died
Friedmann	1949	F	65	cecum and ascending colon	submucosal	malignant growth of ascending colon	died
Dale and Pearse	1950	F	52	terminal ileum, 25 cm.	subserosal	pyloric stenosis secondary to chronic peptic ulcer	recovered
Morgan and Barg	1950	M	60	terminal ileum, 6 inches and entire ascending colon	submucosal	extrinsic inflammatory lesion	recovered
Briggs, Sifre and Overholt	1953	F	37	ileum, 4 ft.	subserosal	intestinal obstruction, duodenal ulcer	recovered
Alstaedt and Fiedler	1954	M	32	left colon	submucosal	polyposis	recovered

influenced the surgeon to perform a resection. The constancy of the symptoms with persistence of roentgen evidence of the disease together with the gross and microscopic picture of the lesion suggest chronicity. This finding is in contrast to the cases of spontaneous disappearance of the cysts. Alstaedt and Fiedler[1] reported a case similar to ours in which resection was also performed. They believed that trial of medical treatment by sterilization of the bowel in suspected cases should be done. Surgical treatment has been recommended[1,16] because of obstruction and persistence of the process. We feel that surgery was the treatment of choice in this patient.

SUMMARY

A case of primary pneumatosis cystoides intestinalis involving the sigmoid colon with clinical, roentgenologic, and pathologic studies is reported.

The symptoms of intestinal obstruction were relieved following resection.

Roentgenologic criteria which lead to the diagnosis and provide differentiation of this entity from multiple polyposis and carcinoma are presented.

Biopsy of lesions accessible to proctoscopic examination should result in a correct diagnosis.

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GALLSTONE ILEUS*

REPORT OF FOUR CASES

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THE high mortality associated with gallstone ileus is a problem that deserves continued close attention. There is general agreement that progress toward the solution of this problem can be made through early surgical intervention based on an accurate preoperative diagnosis.[1,4,5,9]

Although the specific roentgen diagnostic signs of gallstone ileus have been known for many years, the preoperative diagnosis still appears to be the exception rather than the rule.[2,3,4,6,10,11] This paradox is probably best explained by the failure to consider this diagnosis because of the comparative rarity of the condition.

The obstructing calculus in gallstone ileus enters the alimentary canal through a process of tissue erosion with the concomitant formation of an internal biliary fistula. Following the passage of the calculus, gas from the alimentary tract may pass through the fistula into the gallbladder and biliary ducts. This phenomenon almost invariably takes place because gallstones large enough to cause intestinal obstruction necessarily produce large caliber fistulae.

The clinical features of gallstone ileus often have a suggestive pattern. The vast majority of patients are elderly women with the symptoms of intermittent mechanical small bowel obstruction which eventually becomes complete.[1] About one-half of these patients have an antecedent history of gallbladder disease.[8] In the presence of suggestive clinical findings every effort should be made to confirm the diagnosis by means of roentgen examination. Serial examinations may be necessary when the initial examination is inconclusive.

The roentgen diagnostic signs of gallstone ileus have been outlined by Rigler, Borman and Noble.[10] Evidence of complete or partial mechanical small bowel obstruction in combination with any one or more of the following signs is sufficient to establish a diagnosis of gallstone ileus: (1) air in the biliary tree; (2) visualization of a calculus in the intestinal tract; (3) change in position of a previously observed stone.

Recognition of air in the biliary tract is the most valuable diagnostic sign in determining the nature of the obstructing lesion. Air in the biliary tract is synonymous with biliary fistula, with the extremely rare exceptions of emphysematous cholecystitis and air in the biliary ducts that are incompetent due to carcinoma. Therefore, air in the biliary tree in association with intestinal obstruction practically excludes any diagnosis other than gallstone ileus.

To illustrate the roentgen diagnostic signs leading to a diagnosis of gallstone ileus, 4 cases are presented. The diagnosis was established preoperatively in all 4 cases on the basis of the roentgen findings. Surgical intervention was prompt and there were no fatalities.

REPORT OF CASES

Case 1. A seventy-three year old woman gave a history of vomiting and obstipation of ten days' duration when first seen. She had had symptoms in the past suggestive of long standing gallbladder disease. Physical examination revealed a greatly distended abdomen. Roentgen examination of the abdomen disclosed the findings of mechanical small bowel obstruction and in the liver area there was noted a collection of gas which was considered to have the configuration of the biliary tree (Fig. 1). A diagnosis of gallstone ileus was suggested on the basis of the roentgen findings. Immediate surgical intervention revealed a gallstone impacted

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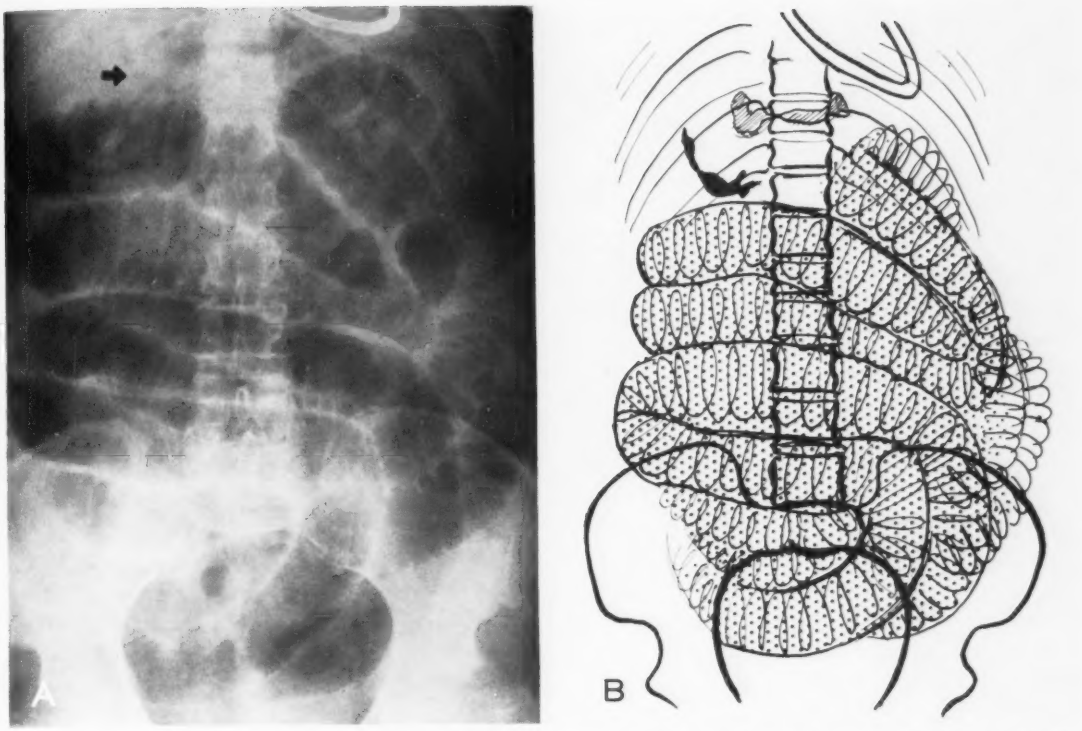

Fig. 1. Case I. (*A*) Air in bile ducts. Multiple distended loops of small intestine with no gas in the colon indicate a probable complete mechanical small bowel obstruction. (*B*) Diagram of *A*.

in the terminal ileum. The stone was removed by simple enterotomy and the patient made an uneventful recovery.

Case II. A seventy-one year old woman had the initial complaint of vomiting of one week's duration. She had had a similar episode of vomiting accompanied by severe abdominal pain two years previously. Clinically, a tentative diagnosis of pyloric obstruction was made and accordingly a roentgen examination of the upper gastrointestinal tract was requested. No abnormality of the stomach was detected but the barium-filled duodenum and upper jejunum were seen to be considerably distended. Several gas-distended loops of small intestine were also noted and little or no gas was seen in the colon. A linear collection of barium suggestive of a biliary fistula was seen in the initial films (Fig. 2). A roentgenogram made one hour later revealed definite evidence of barium in the gallbladder and bile ducts (Fig. 3). On the basis of these findings, a diagnosis of gallstone ileus was made. At operation, two gallstones measuring 2.5 cm. and 3.5 cm. in diameter were found impacted in the mid ileum and in the region of the ileocecal valve. The stone in the mid ileum had

Fig. 2. Case II. Barium in biliary tree. The duodenum and upper jejunum are distended.

FIG. 3. Case II. One hour later. Barium in both gallbladder and biliary tree. Evidence of small bowel obstruction.

perforated the bowel and an early generalized peritonitis was present. The stones were removed and the perforation closed. The patient recovered. In this case, the episode of pain and vomiting two years prior to operation could well have represented intermittent gallstone obstruction with eventual spontaneous passage of a stone through the entire bowel.

CASE III. A seventy-three year old woman had the initial complaints of abdominal distention and vomiting. Roentgenograms of the abdomen revealed distended loops of small intestine and a collection of gas outlining the biliary tree (Fig. 4). A film made after the passage of a long intestinal tube demonstrated a calculus in the lower abdomen (Fig. 5). With this conclusive evidence, the diagnosis was made and at operation a gallstone measuring 3 cm. in diameter was removed from the ileum. The patient recovered.

CASE IV. A sixty-nine year old woman was admitted to the hospital with a history of vomiting for one week and obstipation for three days. Her past history was suggestive of gallbladder disease of long duration. An upright roentgenogram of the abdomen revealed the signs of mechanical small bowel obstruction as well as a small collection of gas in the liver area suggestive of air in the biliary tree (Fig. 6). A supine film demonstrated a large ring-like calcific density having the characteristics of a gallstone (Fig. 7). A diagnosis of gallstone ileus was made and a gallstone measuring 3 cm. in diameter was removed surgically from the ileum. Recovery was uneventful. A subsequent roentgen examination of the upper gastrointestinal

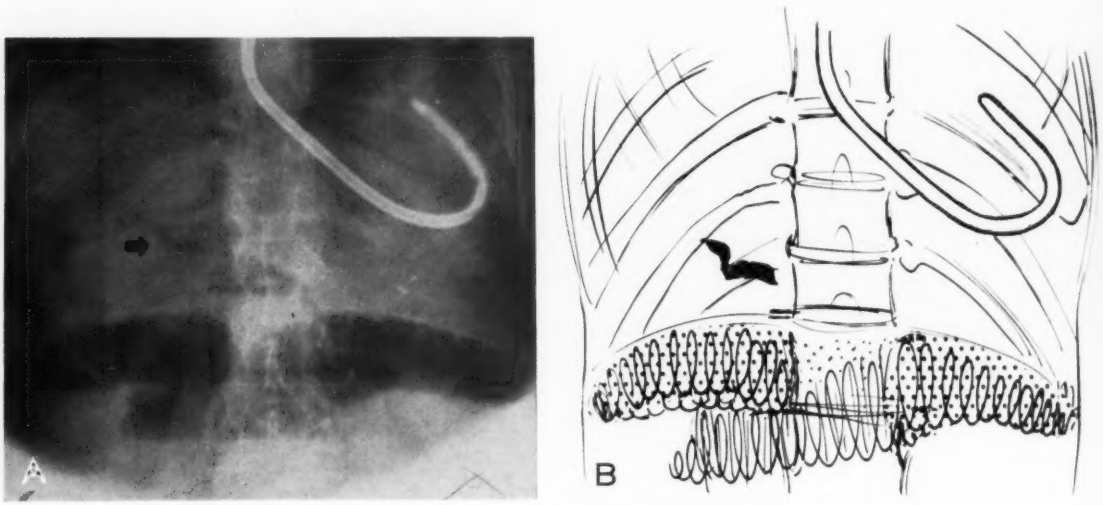

FIG. 4. Case III. (*A*) Upright roentgenogram. Air in biliary tree. Distended loops of small intestine with fluid levels. (*B*) Diagram of *A*.

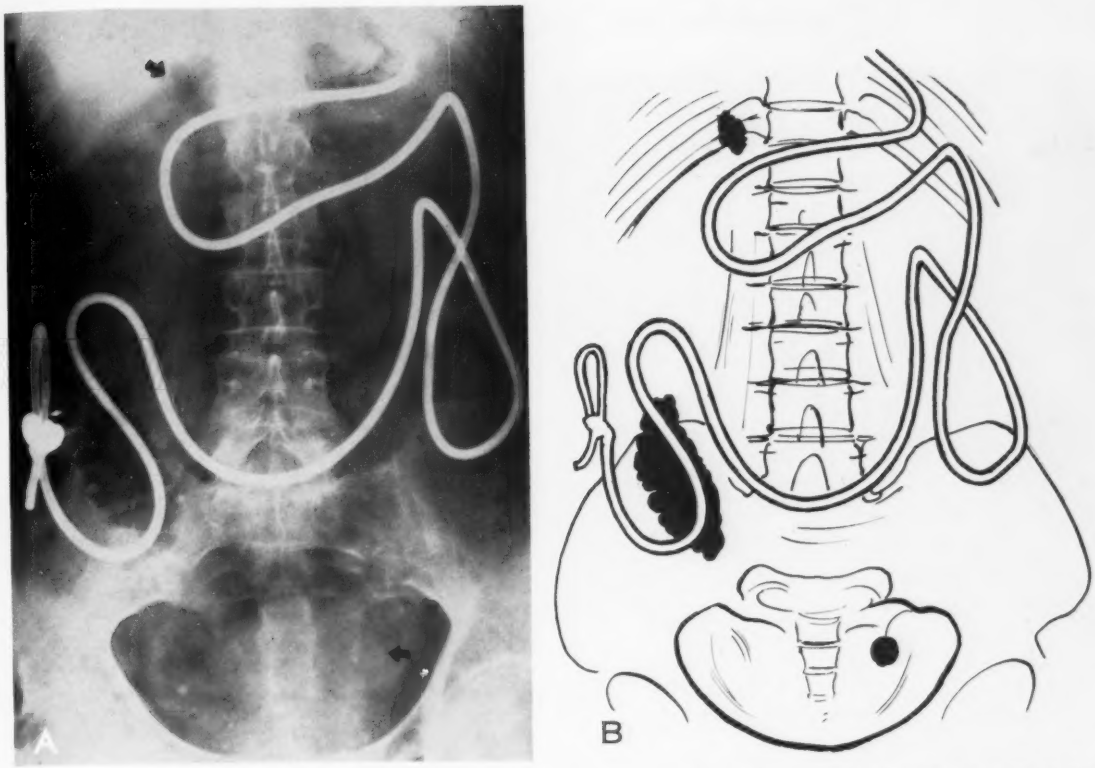

FIG. 5. Case III. (*A*) Decompression of small bowel after passage of long intestinal tube. Gas is still visible in the biliary tree. The obstructing gallstone is visualized in the lower abdomen. (*B*) Diagram of *A*.

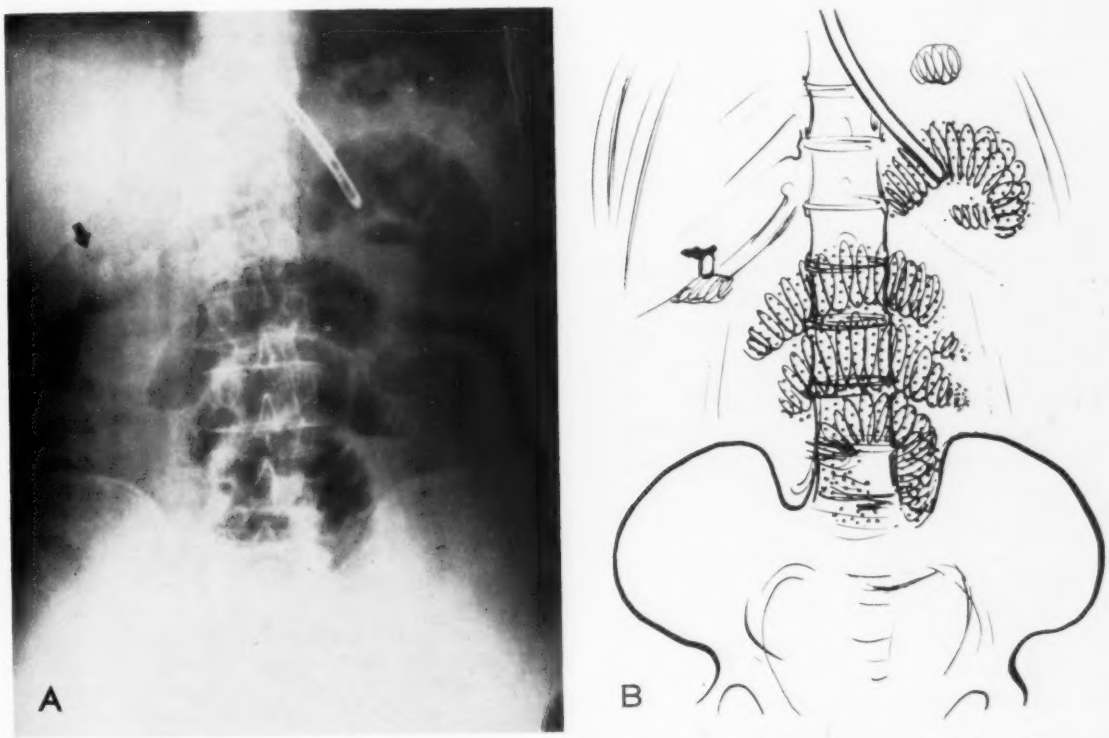

FIG. 6. Case IV. (*A*) Upright roentgenogram. Small collection of gas apparently at the bifurcation of the common bile duct. Mechanical small bowel obstruction. (*B*) Diagram of *A*.

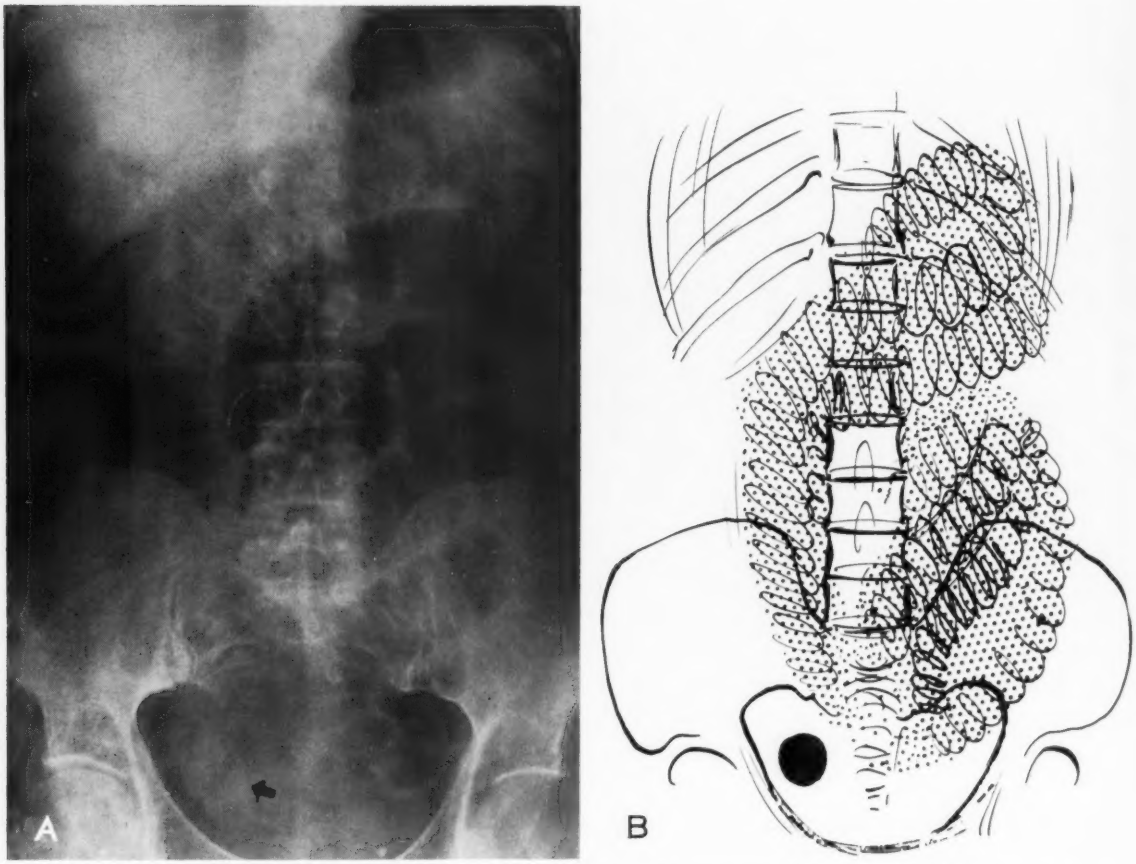

Fig. 7. Case IV. (*A*) Supine roentgenogram. The obstructing gallstone is visible. (*B*) Diagram of *A*.

tract two months later revealed no evidence of a biliary fistula. The fistula had apparently closed spontaneously.

In this group of 4 cases, air or barium in the bile ducts was a constant sign. This sign in combination with the signs of mechanical small bowel obstruction formed the basis for correct roentgen diagnostic evaluation. In 2 cases, conclusive evidence of gallstone ileus was added by the roentgen demonstration of a calculus in the lower abdomen.

CONCLUSIONS

1. In the presence of clinical findings suggestive of gallstone ileus, every effort should be made to confirm the diagnosis by means of roentgen examination.

2. In the majority of cases of gallstone ileus, the diagnosis can be made preoperatively on the basis of the roentgen findings.

3. The known high mortality in gallstone ileus may be significantly lowered by early preoperative diagnosis.

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HIGH KILOVOLTAGE METHOD OF INVESTIGATION OF THE COLON AS A ROUTINE ROENTGENOLOGICAL PROCEDURE

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IN RADIOLOGY, as in the other fields of medicine, there is a continuing search for improved techniques of diagnosis through review of earlier methods, critical examination of present methods and search for new methods. There must always be constant correlation of medical, surgical and pathologic data. New facts brought to light by anatomic, clinical and physical research are continually being integrated into the radiologic field of medicine. Technical improvements such as cineroentgenography, laminagraphy and high kilovoltage techniques, to mention a few, are being produced yearly and are brought to bear on roentgenologic problems to increase diagnostic accuracy. Often, when a limit seems to have been reached in a method of investigation of a certain part of the body, new factors and problems are exposed which allow better, more precise means of investigation. We feel that radiology has been especially sensitive to the urgings of new and better methods and techniques. From the earliest observations on the passage of ingested bismuth to the barium enema and on to the air-barium contrast studies, there has been significant development and improvement which has allowed more accurate diagnosis of the diseases of the intestine. Quite similarly in the field of surgery there has been a continual improvement in the methods of diagnosis and treatment. In the treatment of obstruction and infection, methods are now in use which make the original ones seem understandably crude and even bizarre. With these changes have come reduced mortality and morbidity and, importantly, a change in perspective which has led from the recognition and treatment of the far advanced disease process to the recognition and treatment of the early disease processes among which there is no lesion more important than the colonic polyp. The desire now exists to recognize the smallest polyp possible and to treat it surgically. The question arises as to what can best be done in a routine manner with the least effort, manipulation and exposure as well as with the least discomfort to the patient. The aim is to demonstrate the small polypoid colonic lesion more satisfactorily than is possible by the roentgenologic methods now generally in use. This is a challenge which can be met not only by increased efficiency and broader use of the special examination but, more importantly, by a reliable and sensitive routine method of investigation. In the presence of suspicious signs and symptoms we can employ accepted modalities and we can repeat the examination. However, it is the detection of the asymptomatic lesion which must more seriously occupy our attention at this time. Intensified study of the problem of the polypoid lesion of the colon indicates that a significant number has been escaping our detection and that many of these surreptitiously develop malignant changes. In our series of cases we have found it impossible at times to differentiate between the mucosal polyp, whether benign or malignant, and the extramucosal tumefactions such as endometriosis, secondary carcinomatous implants, localized foreign body reactions in the bowel wall and inflammatory granulomas. For this reason, we prefer to use the term polypoid lesion rather than adenomatous polyp, when describing this finding.

Certain clinical and pathologic facts should be borne in mind. Atwater and Bargen,[1] Bacon and Brood,[2] Castro, *et al.*,[7] Swinton and Warren,[20] as well as others

have shown the intimate relationship between colonic polyps and malignancy. The life cycle of development from simple benign polyp to full blown malignancy has been detailed by careful, competent investigators. This similarity is particularly striking in regard to their common sites, age incidence and multiplicity. Buie[4] has stated that all polyps are cancerous or will become cancerous if they are not destroyed and the patient lives long enough.

STATISTICAL DATA

Recent medical literature including the work of Buie,[4] Swinton,[2] Rider, *et al.*[17] and Burnikel and Schutte[5] contains important statistical information.

Incidence. Between 2–12 per cent of all persons undergoing routine sigmoidoscopic examination are found to have polyps. Fourteen per cent of persons over forty years of age are believed to have colonic polyps. Varying statistics show that 20–40 per cent of polyps are multiple.

Age and Sex. The polyps appear to be quite equally distributed between the male and the female. The average age of the polyp patient is fifty-two years. The incidence increases with advancing age, but polyps have been found at all ages.

Size and Location. Seventy-five per cent of polyps are less than 1 cm. in diameter. Approximately 16 per cent are less than 3 mm. in diameter. Twenty-five to 30 per cent are located above the reach of the sigmoidoscope.

Relationships of Polyps and Carcinoma. Ten to 40 per cent of polyps are malignant in varying degrees. The largest group of malignant polyps are seen in the 3–5 mm. group according to Burnickel and Schutte.[5] There appears to be considerable variation in interpretation of the histologic appearance of polyps. Twenty-five per cent of patients with carcinoma have associated polyps usually in close proximity. Carcinoma of the colon and rectum occurs with five times greater frequency in "polyp patients" than in normal individuals. Patients with multiple polyps are twice as likely to develop carcinoma as individuals with a single polyp.

FIG. 1. Two colonic polyps, one located in the descending and the other in the sigmoid colon. Sixty year old woman. Presence of hemorrhoids and constipation. No rectal bleeding. High kilovoltage barium enema studies demonstrated one sessile polyp in the descending colon measuring 3 mm. in diameter and another in the sigmoid colon measuring 9 mm. in diameter. Both polyps removed by local excision. Pathologic examination proved the smaller polyp benign, the larger malignant. Segmental resection was then performed at the site of the malignant polyp in the sigmoid colon. (Other translucent areas seen in the colon were eliminated as due to polyps by change in size and position in the various projections of the colon.)

Recurrence. Rider, *et al.*[17] proved that new polyps develop in approximately 20 per cent of patients with one polyp and 40 per cent of those with multiple polyps.

ENDOSCOPIC EXAMINATION

Indications are that 30 per cent of colonic polyps are situated in portions of the colon where they cannot be detected by direct vision. The size of the polyp and the type, whether sessile or pedunculated,

Fig. 2. Small pedunculated polyp located in the sigmoid colon. Fifty-three year old woman. Dull aching epigastric pain. No rectal bleeding. High kilovoltage barium enema studies demonstrated a polyp at the junction of the descending and sigmoid colon. The polyp measured 5 mm. in diameter and exhibited a short pedicle. At surgery it could not be palpated. It was located endoscopically through an incision in the descending colon. The polyp was removed by local excision. Pathologic examination proved the polyp to be benign.

do not indicate malignancy or benignancy. It is not possible for the pathologist or proctologist to predicate a benign course for an adenomatous polyp by any known criteria. Of overwhelming importance is the fact that there is no sign or symptom produced by the great majority of polyps. Occasionally, there may be rectal bleeding.

Although it has been stated that 70 per cent of polyps and/or carcinomas are subject to discovery by endoscopic examination, this would appear to be under ideal circumstances and would be modified by such factors as the experience of the physician and cooperation of the patient. Furthermore, a significant number of sigmoid colons are coiled and twisted so that at times only a short segment of the intestine can be brought into view. Bleeding is also a complicating factor. For these reasons a detailed roentgen examination may frequently detect lesions in this area which could be overlooked by endoscopic examination. Here lies a fertile field for roentgenologic study where uniquely the diagnostic roentgenologist has the opportunity to make his greatest contribution to early detection and eradication of

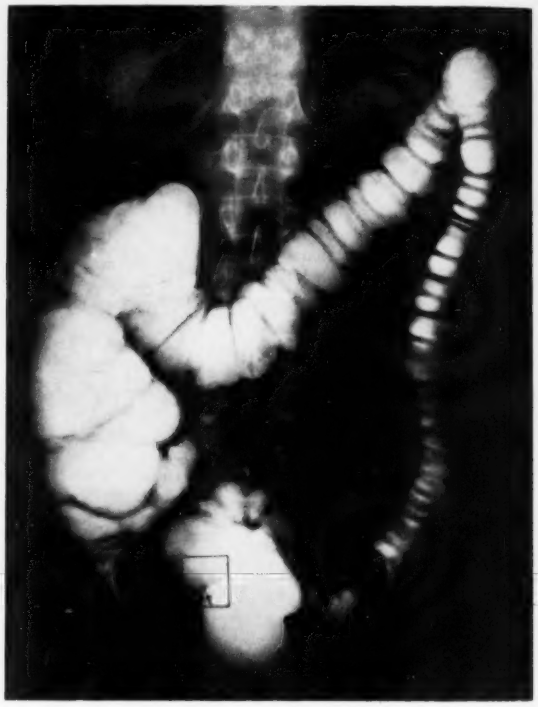

Fig. 3. Small sessile polyp in rectosigmoid area. Forty-eight year old man, hospitalized for evaluation and treatment of duodenal ulcer. Routine sigmoidoscopic examination revealed a small polyp in the rectosigmoid area. High kilovoltage barium enema studies were done to prove or disprove multiplicity. A polyp measuring $4 \times 5 \times 8$ mm. was demonstrated in the rectosigmoid area. There was no surrounding induration. There was no evidence of other polyps. Biopsy and pathologic examination indicated that the polyp was a papillary carcinoma. Segmental resection was then performed. (Multiple exposures in varying projections proved all other similar appearing translucencies within the colon as artefacts which at times may simulate a polyp.)

cancer. For, as has been stated many times in many different ways, the ideal treatment of cancer lies in its prevention.

ROENTGENOLOGIC EXAMINATION

Space filling lesions can avoid detection by the usual barium enema examination, especially in the areas which cannot be adequately palpated and compressed. We are aware of the disadvantages of the barium-air contrast study as a routine procedure despite its many advantages as a special method. Our attention therefore was directed to the work of Gianturco[11] utilizing the high kilovoltage technique.

Fig. 4. Small pedunculated polyp in the transverse colon. Twenty-one year old woman. Was reported to have had colitis in 1949; in 1951 she had rectal bleeding. Sigmoidoscopic examination revealed two small rectal polyps. No other pathologic process was noted. The polyps were removed by local excision. A contrast barium enema examination demonstrated a polyp at the junction of the descending and sigmoid colon measuring 1 cm. in diameter. At surgery the colon was opened and explored. The polyp was located and removed by local excision. Pathologic examination proved the rectal and colonic polyps to be benign. In 1954 the patient had recurrent rectal bleeding. High kilovoltage barium enema studies demonstrated a polyp measuring 5×8 mm. in the left transverse colon. Patient is now awaiting polypectomy.

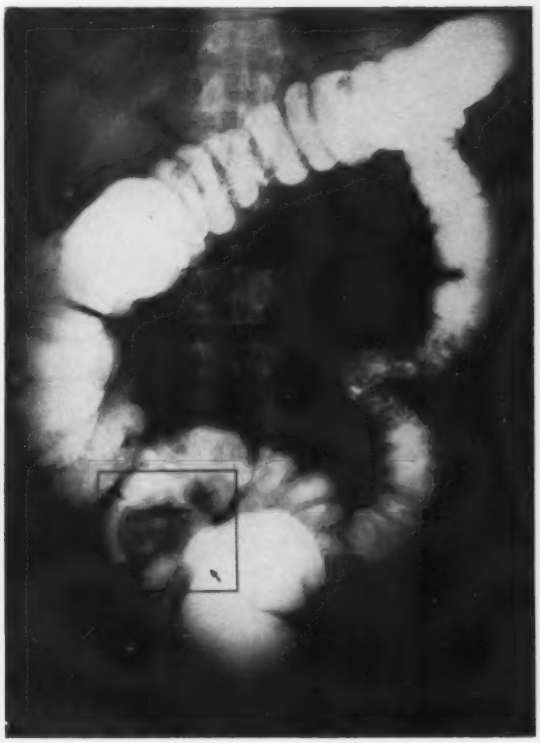

Fig. 5. Large broad based sigmoid polyp. Fifty-two year old man. Afflicted with angina pectoris and questionable duodenal ulcer. Complete gastrointestinal study was done. High kilovoltage barium enema studies demonstrated a polyp 4 cm. in diameter in the sigmoid colon. Biopsy and pathologic examination proved it to be benign. Patient refused surgical intervention.

It is not the purpose of this paper to review in detail the many contributions which have been made to the study of the colon by roentgenologic methods nor to describe all the techniques. This subject has been thoroughly covered by such men as Case,[6] the Cole collaborators[9] and Weber[23,24] who surveyed the work of outstanding pioneers and their valuable contributions. The chain of events started in 1896, when Becker obtained roentgenograms of the colon after filling with lead acetate as well as after inflation with air

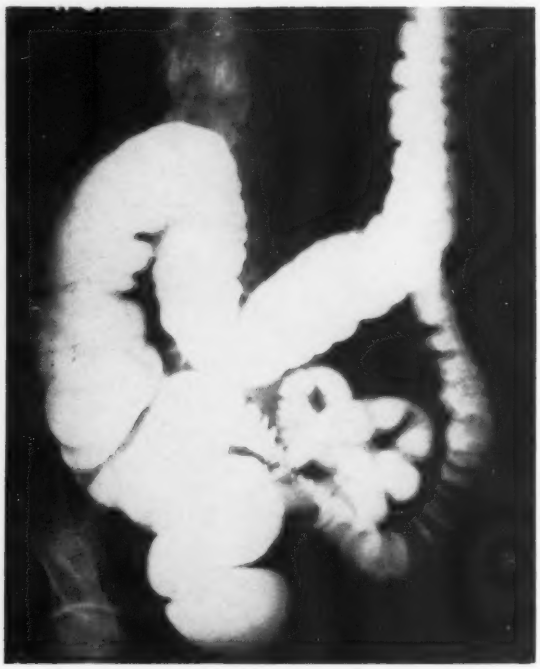

Fig. 6. Endometriosis and benign polyp of the sigmoid colon. Forty-two year old woman. Married. No children. No miscarriages. Regular menstrual cycle every 24 days. Some irregular vaginal spotting of one or two days' duration over the past year. Slight vaginal discharge. No rectal bleeding. No constipation. Dull aching pain in right lower quadrant of abdomen. Hard movable mass in pelvic area felt by abdominal palpation. Pelvic examination revealed large anteverted uterus, the surface of which was studded with several nodular tumors. Barium enema study demonstrated two polypoid lesions in the sigmoid colon, one 2×3×5 cm., the other 6×13 mm. in size. At surgery uterus, tubes and ovaries were removed and resection of the sigmoid was performed. Pathologic report was: early secretory stage with endometrial hyperplasia of uterus, leiomyomata and adenomyosis. Endometriosis of ovary. Endometriosis of sigmoid colon. Polyp in sigmoid colon.

and led through 1950 when Gianturco described the high kilovoltage technique. Important developments during this period were Haensel's studies in showing the superiority of the barium enema over the contrast meal for colonic investigation and Fisher and Weber's work with the barium-air contrast enema. Another notable contribution to the examination of the colon was that of Forssell and Berg in the field of mucosal relief. Within the last few years papers have appeared describing methods of investigation using barium and tannic acid, dilute and colloidal barium, stereoscopic and spot pressure techniques as well as single stage methods of double contrast study. Each of these methods has contributed to the advancement of the accuracy of colon examination.

HIGH KILOVOLTAGE TECHNIQUE

The intention of this paper is to present our experiences and results utilizing the high kilovoltage technique particularly as a routine procedure but also as a special, detailed method of investigation.

Our interest in this problem was brought to a sharp focus by the sudden increase in the number of colonic polypoid lesions detected after introduction of the high kilovoltage technique in 1953. We had previously used the standard barium enema method of investigation which was supplemented by the air-barium contrast method where indicated, especially in bleeding from the lower bowel. It is now our opinion that polypoid lesions are more easily and accurately found and evaluated by the high kolovoltage technique than by any previously used method. The greater penetration of the roentgen rays is an advantage allowing visualization of lesions as small as 3 mm. in diameter. Furthermore, quite often intraluminal lesions hidden by the redundant loops of the sigmoid colon and overriding flexures can more easily be recognized. The dark heavily penetrated films do not show as much contrast as the standard roentgenograms and the soft tissue detail is to a great extent eliminated. Information about the soft tissue detail is obtained, however, in the usual manner, either by a preliminary roentgenogram of the abdomen or at the time of the post-evacuation study. We have noted that diverticula are more easily demonstrated on the well penetrated roentgenograms. This method is especially effective in detailing the various segments of bowel in unusually heavy, obese patients. The same is true of those instances in which the bowel loops

are grossly dilated and redundant as is seen in elderly chronically constipated individuals and in the young child with macrocolon.

The method is simple, without discomfort and requires only routine manipulation of the patient. It is done as a single operation, entailing minimal radiation exposure to the patient. In the majority of cases the polypoid lesion is clearly demonstrated on the initial examination, either exhibiting a pedicle, or producing a dimpling of the bowel or showing an obviously sessile character. We have made it a policy, nevertheless, to prove its presence on two separate examinations. Confusing shadows, not particular to this method, are fecal material in the bowel, gas bubbles and sometimes oil particles. Strict adherence to the preparatory instructions will to a great extent eliminate the troublesome problem of fecal residue. We have had no significant difficulty with oil particles since this is most often due to an overabundance of castor oil. Gas bubbles are, however, unavoidable and will at times necessitate reexamination and re-evaluation of the colonic findings.

The success of any examination of the colon depends to a great extent upon the thorough preparation of the patient. This is particularly true with the high kilovoltage technique where extraneous matter in the bowel is so fully visualized. Good preparation requires the aid of the attending physician. He should explain to the patient why the examination is being done, what is to be done, and should urge his harmonious cooperation. The nursing staff must see that all orders are carried out scrupulously. Most important, the patient must face the necessity of restriction of solid food and the often unpleasant results of castor oil administration. Demands for alteration of the technique will lead only to failure. The amount of castor oil ordered will be varied to some extent with the size of the patient and past reaction to castor oil. It may have to be withheld completely when there is a history and/or signs of appendicitis, ulcerative colitis, enteritis, irritable bowel, serious cardiac disease, severe lower intestinal bleeding and obstruction.

FIG. 7. Foreign body granuloma at colonic anastamosis. Sixty-four year old man. Resection of part of the transverse and descending colon with end to end anastomosis—August, 1953 for carcinoma. Following surgery he developed a large ventral hernia. Has since developed a partial intestinal obstruction with increasing constipation. Barium enema study demonstrated an intraluminal polypoid lesion at junction of transverse colon and descending colon at site of anastomosis. Local surgical excision was done when frozen section showed no malignancy. Pathologic report indicated a foreign body granuloma about suture material.

In general our preparatory orders are as follows: 1. Two ounces of castor oil between 6:00 and 7:00 P.M. 2. Omit supper and also breakfast on the succeeding morning. 3. Three warm, mild soapsud enemas, not exceeding one and one half pints, at fifteen minute intervals, beginning approximately at 6:00 A.M. 4. Examination of the colon to be done during the morning. During the period of fasting, patients may partake of moderate amounts of clear fluid leaving no

colonic residue—water, tea without cream, coffee without cream and sugar.

One of the particular advantages of the high kilovoltage technique lies in the fact that fluoroscopy can be carried out in the usual manner since only slight dilution of the barium mixture is necessary. This is in contrast to several other methods utilizing significant dilution of the contrast mixture whether it be thin barium sulphate mixture, so-called colloidal barium, or one of the variations of thorium solution. The fluoroscopic examination is of great value. With this procedure some behavior patterns of the colon can be studied, so important, for example, in early inflammatory disease. The presence or absence of extrinsic masses can best be determined by palpation and fluoroscopy. The flow of the fluid can be regulated to the patient's comfort and the proper degree of filling ascertained. Overdistention in obstructed colon and irritable inflamed bowel can be avoided.

Before the administration of the barium clysma, the procedure should be explained to the patient, and he should be reassured. This frequently contributes to the better relaxation of the bowel. The barium is then administered without undue pressure and with palpation of the colon. We mix 16 oz. of 1x barium with 96 oz. of water at 105° F. This produces a barium mixture which gives good fluoroscopic detail and is well penetrated by the high kilovoltage. We vary the number of roentgenographic exposures and projections depending upon the coiling, position, length and overriding of the various segments of the colon. Frequently, we halt administration of the enema at the mid transverse colon and obtain films in oblique projections with or without spot roentgenograms. At other times standard anteroposterior and posteroanterior roentgenograms in the right and left oblique views will suffice. A post-evacuation film is then obtained which in the great majority of instances outlines the terminal ileum and shows soft tissue detail. The technical factors are 120 kv., 300 ma., with variation of time according to size. A 16 to 1 grid is mandatory. The practical and theoretic aspects of the high kilovoltage technique have been fully presented by Trout, *et al.*[22]

RESULTS

Our report is based upon 1,000 consecutive barium enema examinations performed since the high kilovoltage technique was instituted using the barium mixture described. We have tried to standardize all the factors which can be standardized. We have attempted to be as consistent in our procedure as possible. However, in a general hospital such as ours, certain factors are difficult to control as, for example, the thoroughness of preparation of the bowel and the restriction of diet to our prescribed standard not only in regard to the out-patients but also the in-patients. One technician is likely to be more conscientious in preparation of the barium mixture than the other. The purpose of this paper, therefore, is to indicate the results which can be obtained by this method with reasonable control of the various factors involved.

We feel that these results will be improved upon in the future mainly through utilization of better barium preparations and through more efficient purgation. We are in complete agreement with the ideas and suggestions so ably expressed by Paul Hodges regarding the present inferior barium products and the need for more intensive study in this field. There is an undoubted need for a contrast material of improved quality with finer dispersion, lack of sedimentation, satisfactory density so as to be penetrable by the roentgen rays of higher kilovoltages such as 120 kv. and also with good adhesive qualities which will cause it to adhere to the colonic mucosa. Furthermore, purgation of the colon can undoubtedly be improved upon. Castor oil still appears to be the best cathartic. Better results may be obtained by administration twenty hours before examination. It may prove more advantageous to extend the period of liquid non-

residue diet to the entire day preceding the colonic study. It is to be hoped that research in purgatives will produce a more effective product which would still be safe and not too uncomfortable for the patient.

Review of the 1,000 examinations indicated that diverticulitis was present in 180 patients, carcinoma was found in 28, and polypoid lesions were demonstrated in 31. Only the polypoid lesions are considered here. Of the 31 polypoid lesions, 6 were nonadenomatous; 1 a secondary transplant from carcinoma of the ovary; 3 endometriosis; 2 foreign body reactions at old operative sites and 1 an inflammatory granuloma at the cecal tip. The remaining 25 were mucosal polyps. The incidence of all polypoid lesions was 3.1 per cent indicating that the importance of roentgenologic recognition and surgical intervention cannot be over emphasized. A heavy responsibility lies with the physician who would attempt to guess the nature of the lesion. It is particularly significant that in 74 per cent there was no bleeding to warrant any of the special colonic examinations which have been at our disposal. A substantial number of the polyps in all probability would have remained undiscovered, especially the small ones. The greater proportion of these patients were referred for examination because of such complaints as irregular bowel habits, constipation, diarrhea, abdominal soreness, cramps, excess gas, loss of weight, anemia, abdominal mass or previous history of colonic disorder.

Although in a high percentage of cases the polyp could be accurately identified by its typical appearance as a pedunculated mass, obviously sessile deformity or dimpling of the bowel at the site of the intraluminal lesion, if the presence of the polypoid growth could not be confirmed by sigmoidoscopic examination, we requested re-study. In our series diagnosis was verified by surgery and microscopic analysis in 25 patients and by repeat roentgen study in 6 patients who for reasons of age, poor physical condition or refusal of further investigation were not subjected to operative intervention. The average age of the patients was fifty-two years. Seventy per cent were female, which for some unknown reason is considerably higher than any previous figure presented. Three polyps were located in the cecum and ascending colon, 21 in the sigmoid colon and 5 in the rectum. These figures give an incidence of 65 per cent in the rectosigmoid area and of 35 per cent in the remaining segments of the colon. Thirty-five per cent of the polyps were pedunculated, 65 per cent were sessile. The size of the polyps varied from 3 mm. to 4 cm.; in 40 per cent it was 10 mm. or less. Sixty-nine per cent of the polyps were benign, 25 per cent were malignant and 6 per cent were not available for microscopic study. Multiple polyps were disclosed in 35 per cent of the cases. There were no patients in whom congenital familial polyposis was found. We did not include patients with chronic ulcerative colitis exhibiting pseudopolyposis. Size and configuration gave no indication as to the malignant nature of the lesion; the largest polyp which measured 4 cm. in diameter was benign, and one of the smallest which measured $4 \times 5 \times 8$ mm. was malignant.

Since high kilovoltage technique allows discovery of more and smaller polypoid lesions, there must necessarily be close cooperation between the physician, surgeon and radiologist. It is recommended that any patient in whom a polypoid lesion has been discovered sigmoidoscopically be also examined roentgenologically. The multiplicity of these lesions has been well established. Every patient with rectal bleeding, especially in the older age group, must be likewise examined. Every patient who has had a polypoid lesion or carcinoma should be examined periodically. Once the presence of the lesion has been definitely demonstrated by roentgen examination and the lesion is beyond the reach of the sigmoidoscope, an operation should be performed, except for obvious contraindica-

tions in the patient's physical condition. The size and configuration of the polypoid lesion are no criteria for malignancy. Exact localization of the polyp by roentgen examination is of decided advantage in view of the fact that the surgeon not infrequently has difficulty in finding the small lesions. Palpation of the bowel may be totally inadequate and a direct inspection of the open bowel may be necessary to localize the small lesion. An inch by inch study of the mucosa is sometimes required. The radiologist should make himself available to aid in the exact localization of the polyp at the time of surgery especially in detecting the small evasive lesion. On more than one occasion the surgeon has closed the bowel stating that no polyp was present only to have it proved on subsequent roentgen examination, necessitating re-operation and removal.

SUMMARY

1. The high kilovoltage technique is an efficient method for detection of polypoid lesions in the colon not only as a routine method but for special examination.

2. The method is simple and time conserving.

3. One thousand consecutive barium examinations yielded 3.1 per cent polypoid lesions, 2.8 per cent carcinomas, and 18.1 per cent diverticula.

4. Size and configuration of the polypoid lesion did not indicate malignancy or benignancy.

5. Bleeding from the bowel was an unreliable indication for detection of polypoid lesions. Only 26 per cent caused rectal bleeding.

6. Multiple polypoid lesions were present in 35 per cent of the patients examined.

7. Twenty-five per cent of the polypoid lesions were malignant.

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Dr. Jarre's suggestions and assistance contributed greatly to the preparation of this paper.

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POLYPS OF THE COLON: HOW TO FIND THEM*

BARIUM ENEMA, DOUBLE CONTRAST, FLUOROSCOPIC IMAGE AMPLIFICATION, OR WHAT?

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CARCINOMA of the large intestine is the cause of 17 per cent of all deaths from cancer. Carcinoma and polyps of the colon are distributed similarly and are frequently associated in the same patient and in the same area. A certain proportion of grossly benign polyps show histologic malignant changes. There is, therefore, general agreement that the frank carcinoma of the colon was once a polyp, although there is no general agreement as to just what proportion of polyps become malignant. One authority says 6 per cent, another 60 per cent. But one may well conclude that the reduction of mortality from carcinoma of the large intestine depends upon the detection of these tumors before they have become invasive or have metastasized. It is the radiologist's task to find as many of them as he can. As he discovers more and more of these small tumors the question of what to do with them will arise more often. Should they all be removed or may some be watched? But the lesion that has not been demonstrated can neither be eradicated nor kept under observation.

For roentgenologic demonstration of polyps, Weber[22] relies on fluoroscopy and the double contrast method that he has been so instrumental in developing. He performs the latter when specifically indicated. He feels that it will demonstrate lesions measuring approximately 1 cm. or larger and that it is a reliable method, but that he would base a diagnosis on fluoroscopic observations alone.

Moreton[11] believes that a double contrast study is an ideal primary routine, not only for polyps, but for other lesions, and advocates anteroposterior and posteroanterior views to change the relations of air and excess barium. He admits that the major usefulness of the routine air contrast procedure is in the demonstration of polypoid lesions.

Garland, however, states that he would not subject 95 to 98 per cent of *his* patients to the "discomfort, hazard, and expense" of a routine double contrast study for the sake of the other 2 to 5 per cent.

Stevenson[18] has reported the results of a study which he carried out to determine the desirability of a routine double contrast examination in every patient, as advocated by Moreton. In 500 patients with a history of bleeding from the bowel, of previous polyps, or of polyps visible by sigmoidoscopy, he found, by the double contrast method, polyps in 25 instances, or 5 per cent. In each of two groups of 500 patients without symptoms, he found two polyps, an incidence of 0.4 per cent. He concluded, therefore, that a routine double contrast study is not worthwhile except when indicated by the history but that it is the only method that can show polyps less than 1 cm. consistently.

Templeton and Addington[21] combine the single and double contrast studies. They developed a three-way valve which clamps to the table and facilitates filling the colon, evacuating it partially, or introducing air. The evacuation is accomplished by attaching the outflow channel to a source of negative pressure. Aside from emptying the colon sufficiently for double contrast study, this controllable drainage permits overlapping loops, particularly those in the sigmoid and rectosigmoid, to be separated and separates the cecum from the sigmoid when these overlap each other. It also renders the procedure more comfortable for the patient. By reducing the amount of

* Presented at the Fifty-sixth Annual Meeting of the American Roentgen Ray Society, Chicago, Illinois, September 20–23, 1955.

barium in the bowel, fluoroscopy and spot filming are facilitated. Templeton and Addington believe that by this combination of opaque and double contrast methods, made practical by the three-way valve, the frequency of error has been reduced. However, they state that polyps less than 1 cm. usually escape detection.

Jones, Kaplan and Windholz,[10] were instrumental in developing baridol, one of the first of a long line of "colloidally stable" barium suspensions now on the market. They prefer double contrast studies to detect polyps, and perform this procedure, but only if specifically indicated, about two days after the single contrast examination. They believe that baridol gives a smooth even coating, resistant to drying out in the colon. They advocate the views of Fischer —upright position and right and left lateral decubitus roentgenograms taken with the beam horizontal. This changes the relationship of barium and air so that, in theory at least, large parts of the air-distended colon will at some stage be shown with a uniform coating of barium into which the polyp, also evenly coated, can project. Fecal debris and excess barium will drop to the floor of the loop. They believe that the use of baridol and the additional views have definitely improved their results.

Not all authorities agree that the double contrast method is the best for demonstrating polyps. Christie, Coe, Hampton and Wyatt[3] advocate postevacuation studies after 1 per cent tannic acid has been added to the barium suspension. They state this improves the mucosal pattern and encourages more complete emptying of the colon. Ninety per cent of the polyps in their series were noted on postevacuation studies. They believe that the postevacuation roentgenograms will usually show polyps larger than 1 cm. They saw no polyp in the double contrast study that they had not already demonstrated by other methods. They stress, however, that no one method is infallible, and therefore they combine fluoroscopy and spot films, etc., with the evacuation studies. Unlike Weber, they would not rely on a fluoroscopic observation without confirmation by roentgenograms.

Swenson and Wigh, and many other radiologists, rely a great deal on spot filming under fluoroscopic guidance, supplemented by double contrast studies when indicated by their examination or by the history.

Besides the advocates of the advantages of the postevacuation studies, fluoroscopy, spot filming, double contrast methods, or a combination of these, there are those radiologists who stress the advantages of "over-penetrated" exposures of the filled colon. They employ a barium suspension of such density that it can be made translucent by ordinary voltage or else they use a denser mixture which is made translucent by higher kilovoltage. Polyps, because of their intraluminal nature, are demonstrated as dark "holes" in the semi-opaque barium column. Chief among the advocates of such methods are Potter and Gianturco.[6]

Potter's suspension consists of 4.5 gm. of barium per quart of water and the films are exposed with 85 to 100 kv. He uses the method routinely, claiming that it permits him to detect fairly consistently small or large, asymptomatic or symptomatic polyps. He has been able to demonstrate a large number of multiple polyps, which he believes are present in 30 to 40 per cent of patients with polyposis. He feels that the thinner mixture is superior to the denser mixture which requires high kilovoltage to render it translucent, because the loops can be more readily penetrated where they overlap or where large masses of barium collect, as in the cecum.

Gianturco objects to these dilute suspensions because he feels that they settle out too quickly and give poor fluoroscopic images. He advocates a method that he has perfected over the past twenty years. He employs a barium to water ratio of 1 to 4 (by volume) and high kilovoltage to secure adequate penetration, although he has used this latter term at various times to

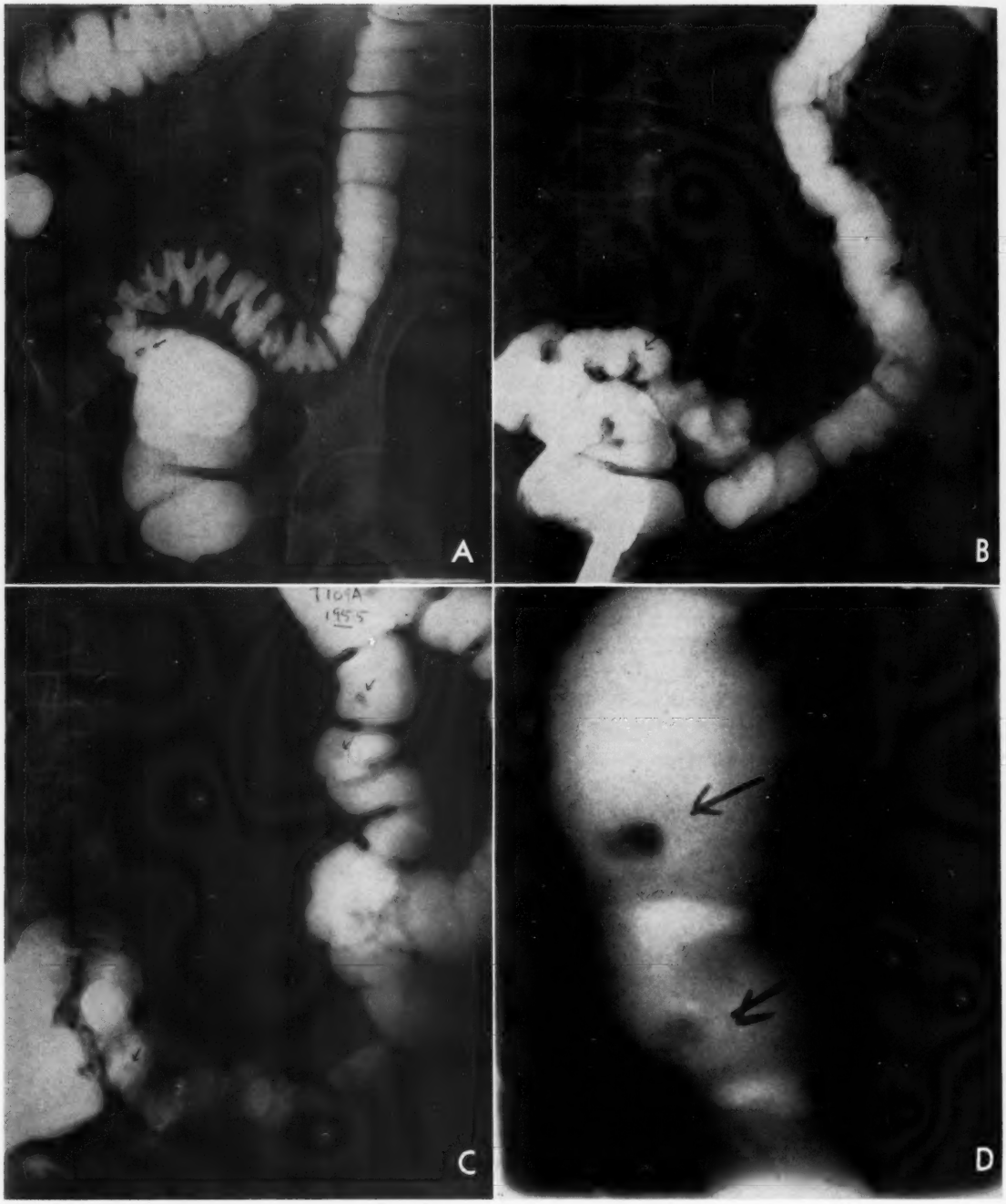

Fig. 1. (*A*, *B*, *C* and *D*) The single contrast study is capable of revealing small lesions if penetration is adequate. More penetration would have been better in each of these three cases. Less penetration would not have been adequate. Note advantage of routine oblique view in uncoiling sigmoid loop in *C* (Case III). Proximal polyp has characteristic double density produced by polyp superimposed on pedicle. Spot film *D* (Case III) shows this better because penetration was more satisfactory, although the spot films were taken at 90 kv. and the 14×17 inch roentgenogram at 115 kv. High kilovoltage is just a means to adequate penetration, not an end in itself.

refer to 90, 100, 110, and now 120 kv., as apparatus has become more powerful. He uses fluoroscopy and spot films to some extent, and evacuation and double contrast studies rarely, depending principally on his "over-penetrated" anteroposterior, posteroanterior, and oblique films, obtained by high kilovoltage technique. Usually he checks defects by the same method. He believes that this procedure is far simpler than any other. The barium suspension is approximately as dense as those commonly used for fluoroscopy, yet roentgen rays of moderately high voltage generally available in modern equipment can penetrate through the barium instead of merely showing the contours of the colon. He claims that this routine retains the value of the other features of the single contrast method and considerably increases the possibility of demonstrating large and small, often unsuspected, intraluminal tumors.

Gianturco and Miller[7,8] have reported several series studied by this high kilovoltage single contrast technique. The results have been about the same in every group. The last group consisted of over 3,500 patients. The barium enema study was usually performed as part of a general examination in conjunction with gallbladder, upper gastrointestinal and other examinations on the same morning. In such a relatively unselected series of cases, polyps were detected in 79 patients, or 2.3 per cent of which 40 per cent were less than 1 cm. in diameter, several were multiple, and, more important, 60 per cent were asymptomatic. Not satisfied with these accomplishments, Gianturco and Miller have recently advocated routine rectoscopy. They perform this in the department of radiology just prior to the barium enema study if the patient has no symptoms. Proctosigmoidoscopy by the proctologist is carried out on patients with a suspicious history. In such cases the barium enema examination is not made until the following day. These added procedures have revealed otherwise undetectable polyps in an additional 5.8 per cent in patients without symptoms, and 12 per cent in patients with symptoms.

AUTHOR'S METHOD

The author, at one time or another, has employed practically all of the procedures mentioned. Some of these he has discarded, and some he has modified, but he has had no great part in the actual development of any of them.

Gianturco and Miller, the author's experience indicates, are substantially correct in claiming that the high kilovoltage single contrast method is a sensitive method of examination and will reveal a large proportion of asymptomatic, as well as symptomatic, polyps; that it generally will be found to be superior to double contrast methods in detecting these lesions, not only in diagnostic yield but in the ease with which the procedure can be combined with the study of the colon for other lesions; and that no study of the large intestine is complete without such an examination.

The author's method is more elaborate than that advocated by Gianturco and Miller. The emphasis is on single contrast high kilovoltage as the basic feature of the examination, but the high kilovoltage technique is combined with diligent fluoroscopy and extensive spot filming of the sigmoid and the contiguous portion of the descending colon, because 70 per cent of the polyps of the large bowel are located here and more distally. Siphonage and "tannic acid" postevacuation studies are also employed, and more recently the electronic fluoroscopic image amplifier has replaced the standard fluoroscope. This single contrast examination in its elaborated form is routinely employed for all patients over fifty years of age, regardless of history, inasmuch as about 15 per cent harbor tumors in the large intestine. It is also the primary procedure in the investigation of polyposis of the large intestine at any age. The examination is somewhat modified for younger patients

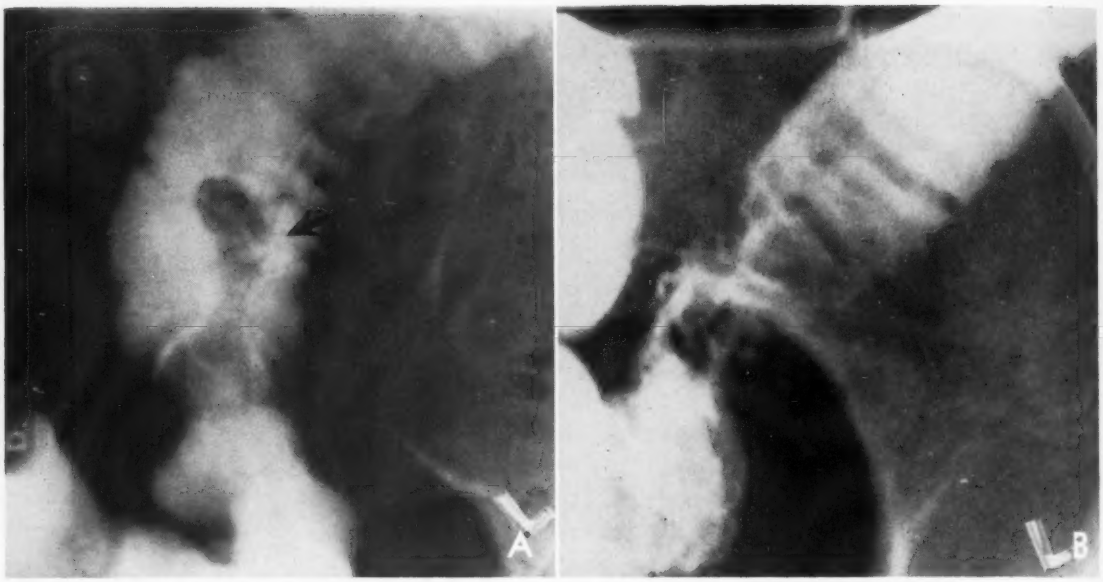

Fig. 2. (*A* and *B*) Spasm, gas, fluid, or debris can obliterate the shadow of a polyp. Spot films *A* and *B* taken within seconds of each other. This is most likely to occur at junction of descending colon and sigmoid. Compare with Figure 10*A*.

who have no indication for such a complete study. A double contrast study is performed at a later date in case of suggestive history, if the single contrast study is inconclusive or if it demonstrates a suspicious defect, and to rule out or demonstrate additional lesions.

The examination described by the author serves as a reasonably thorough roentgenologic study of the colon for any lesion, inflammatory or neoplastic. It is moderately time-consuming and expensive, but it is not nearly so expensive as a misdiagnosis. Actually, a properly penetrated film of the filled colon is no more costly than an underpenetrated one, but it yields more information. Routine spot films of the distal colon scatter no more radiation than those of the splenic or hepatic flexure, but they locate more polyps.

A good part of Gianturco's success with his technique, designed to give considerable information economically and rapidly as part of a general survey, can be attributed to the excellent control he is able to maintain over every feature of the examination, especially in preparing the colon and in obtaining routinely well penetrated films. The properly cleansed colon is probably the most important feature of any study, second only to the intelligence and diligence of the examiner. In Gianturco's clinic a trained employee gives each patient a series of tap water enemas until the return is clear. In addition, there is preliminary preparation by castor oil and enemas at home. Sufficient time is allowed before the barium enema examination is begun so that there is no excess fluid in the colon.

The author is not so fortunate in controlling the conditions under which he is forced to operate. A review of his material indicates that if he relied entirely on Gianturco's abbreviated technique, he would miss some lesions, or would be forced to repeat many studies, usually because of underpenetration or inadequate preparation.

The addition of the features of Gianturco's over-penetration technique to the one already employed by the author, however, has definitely increased the number of polyps discovered, particularly in asymptomatic patients. The improvement has been most striking between the cecum and the sigmoid. Thirty per cent of polyps will be found distributed in the proximal three-fourths of the large intestine, but it is im-

possible and even undesirable to attempt to cover the entire length by spot filming. Not infrequently the high kilovoltage roentgenograms will also call initial attention to polyps in the sigmoid and they may confirm the permanence of a defect which may be questionable or visible on only one spot film. They may demonstrate it even more characteristically. Obviously spot films at 90 kv. do not give the penetration of roentgenograms at 110 and 120 kv. The spot films are advantageous where compression, palpation, siphonage, selective rotation of the patient, etc, reduce the mass of barium to be penetrated and are the ideal means of confirmation, since the permanence and nature of the defect can be demonstrated quickly, economically and repeatedly.

The number of polyps, particularly asymptomatic polyps, discovered by the single contrast method will vary greatly with the type of patients. For example, if one draws his patients from a proctology clinic, from a hospital, or an older age group, he will or should be able to find a greater number of polyps by far than if his patients come from a general survey group in whom the barium enema is often part of a routine study of the upper gastrointestinal tract, gallbladder and large intestine. The percentage of small and asymptomatic polyps in the author's series, all from a private office practice, has grown greatly as experience has developed better criteria and a higher index of diagnostic acumen. About 35 per cent of the polyps detected are asymptomatic and about a similar percentage are less than 1 cm. in diameter. The bleeding may actually be caused by hemorrhoids, fissures, etc., but this did lead to an investigation of the colon. The percentage of polyps which are actually asymptomatic, therefore, is probably greater than the statistics would indicate, as Gianturco has pointed out.

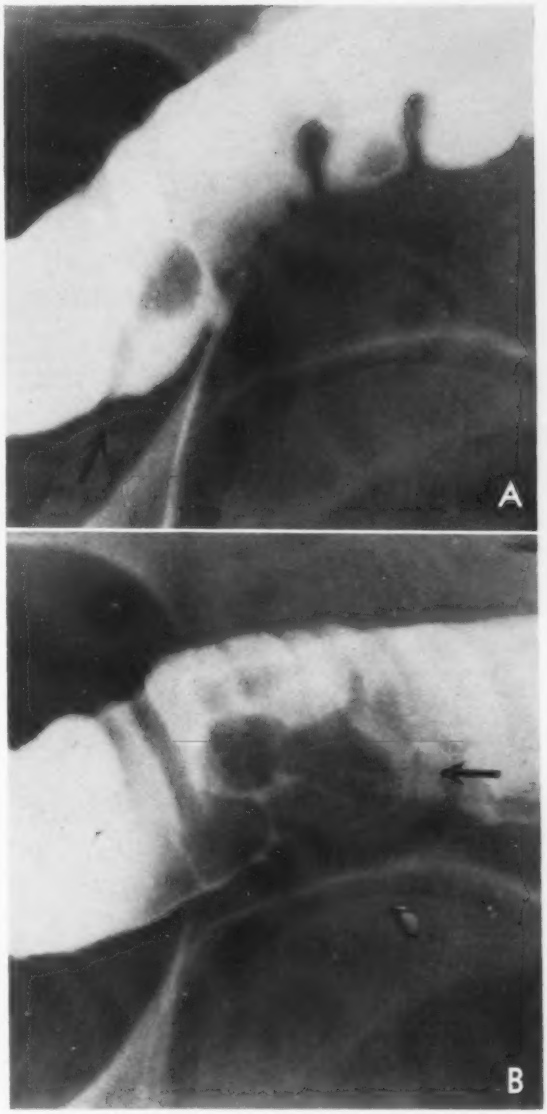

Fig. 3. (*A* and *B*) Pedunculated polyps shift position readily and may be demonstrated at one moment, or in one view, and not in another. Previous partial resection of transverse colon for carcinoma. Recurrent bleeding, which ceased after removal of polyp.

TECHNIQUE

Cleansing of the Large Intestine. There seems to be a diversity of opinion regarding cleansing of the large intestine. Swenson and Wigh believe that purgation is rarely indicated and that morning cleansing enemas are usually enough. Christie, Coe, *et al.*[3] would purge even at the risk of bleeding. Hodges[9] considers cleansing enemas, as ordinarily carried out, useless. Moreton[11] uses one ounce of castor oil, believing that two seem to produce confusing oil droplet shadows. Jones, Kaplan and Windholz[10] have not encountered this difficulty and so use two ounces of castor

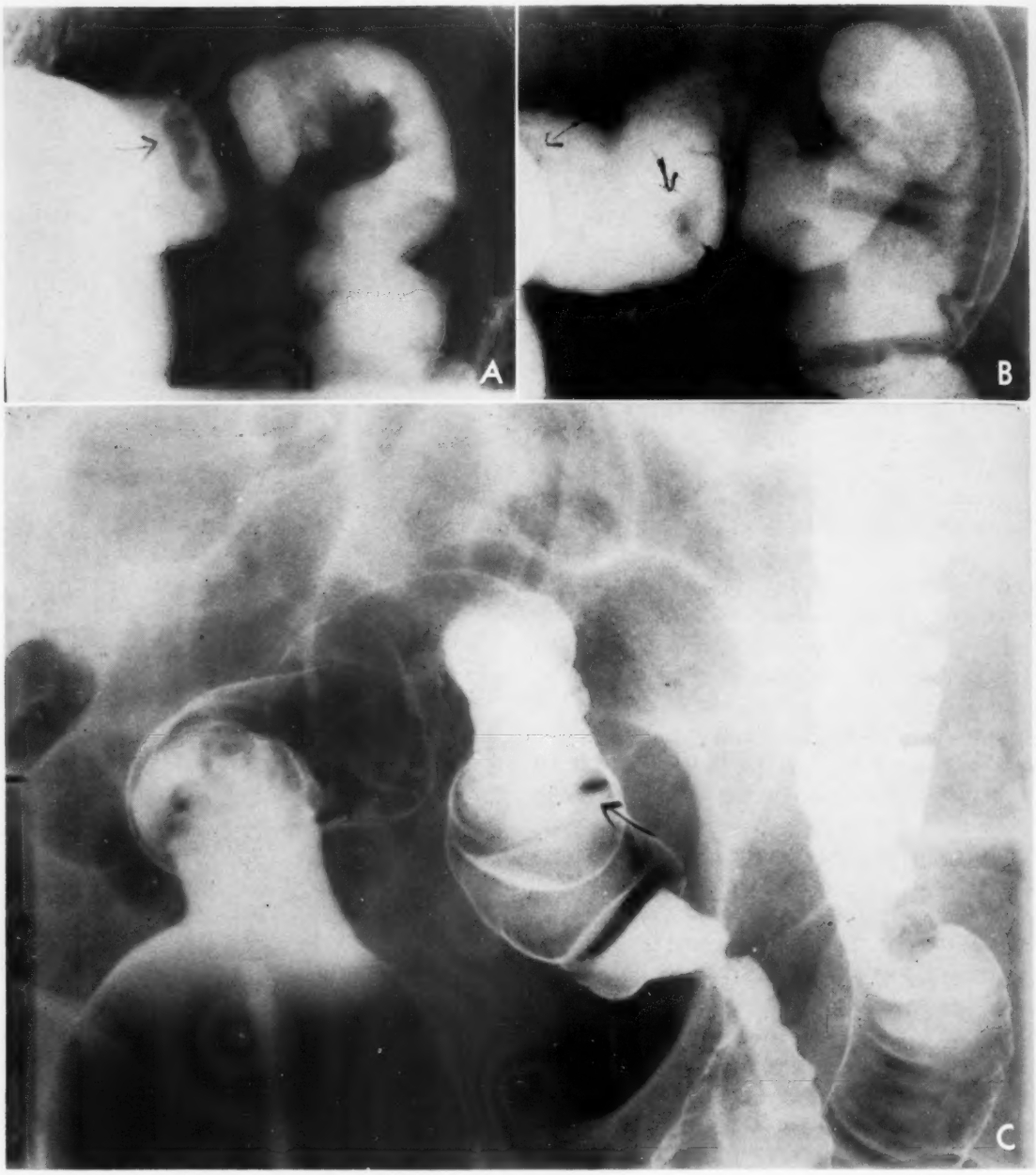

Fig. 4. (*A*, *B* and *C*) Polyps are often multiple. No bleeding. Examined because of large incarcerated inguinal hernia. Two polyps shown. Three found at surgery. Not demonstrated at two previous examinations. Note in Figure 4*B* double defect of polyp of pedicle and polyp superimposed. In Figure 4*C* double contrast study shows one polyp as plus and one as minus defect.

oil. Hodges recommends two ounces so that the patient will be certain to ingest one ounce. Gianturco's preparation, as already described, is the closest to an ideal one, but it is obviously difficult to carry out in the usual office or department. Yet the over-penetration technique is so revealing that one soon becomes aware of the frequent inadequacy of the usual routine preparation.

At the present time, the author is using a routine similar to that recommended by

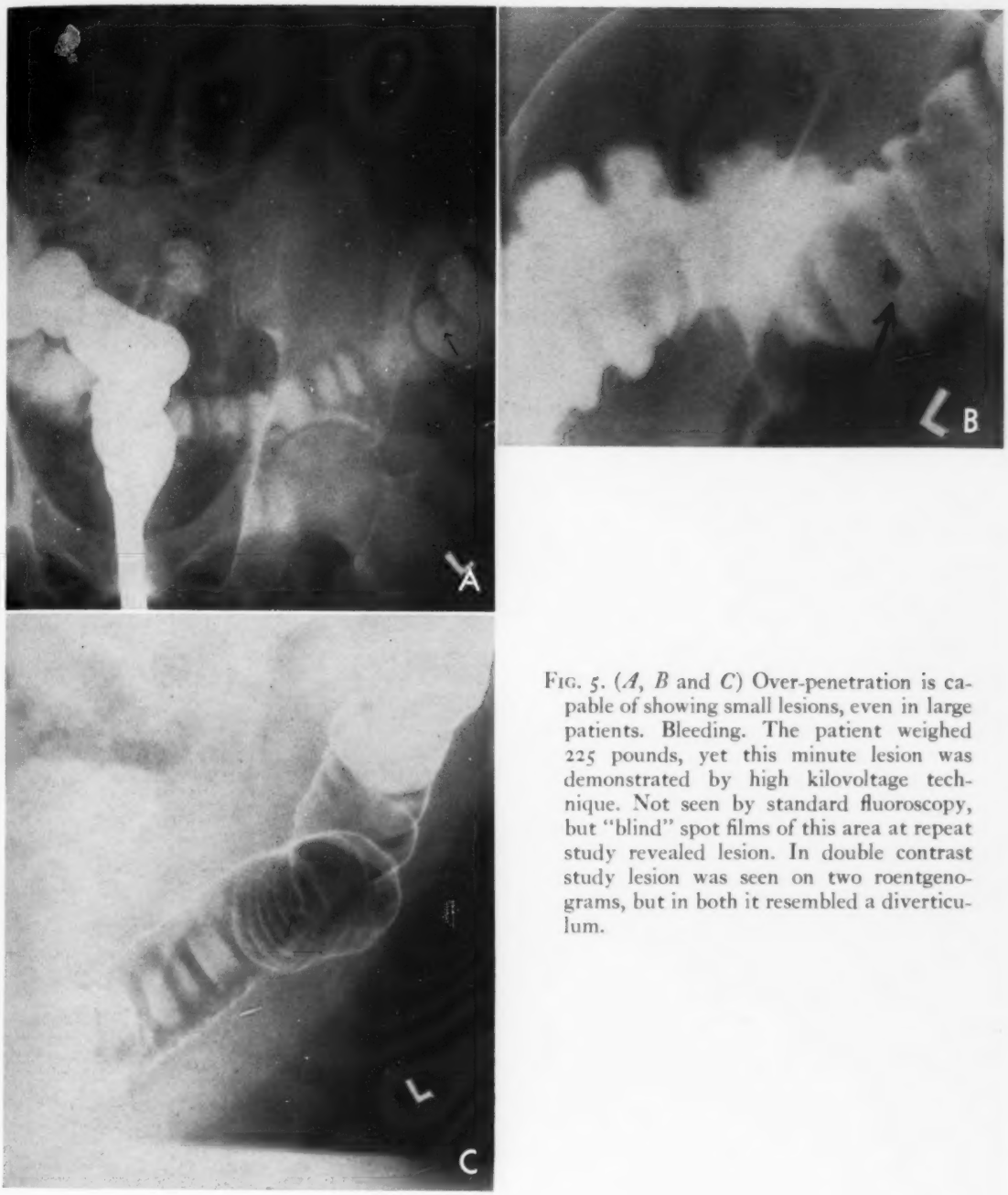

Fig. 5. (*A*, *B* and *C*) Over-penetration is capable of showing small lesions, even in large patients. Bleeding. The patient weighed 225 pounds, yet this minute lesion was demonstrated by high kilovoltage technique. Not seen by standard fluoroscopy, but "blind" spot films of this area at repeat study revealed lesion. In double contrast study lesion was seen on two roentgenograms, but in both it resembled a diverticulum.

Hodges.[9] A nonresidue diet of clear liquids such as water, tea, coffee, fruit juices (without pulp), and clear soups for at least twenty-four hours before examination, in conjunction with two ounces of castor oil taken about twenty hours before the examination (*i.e.*, about 4 P.M.), seems to be satisfactory. Milk and its products and a solid supper are forbidden. Some overenthusiastic patients ingest fluid almost to the stage of edema, so the patient is not allowed to drink anything within two hours of the examination.

Quite often when a proctologist requests the radiologist to perform a barium enema study shortly after he has completed his

A
B
C
D
E
F

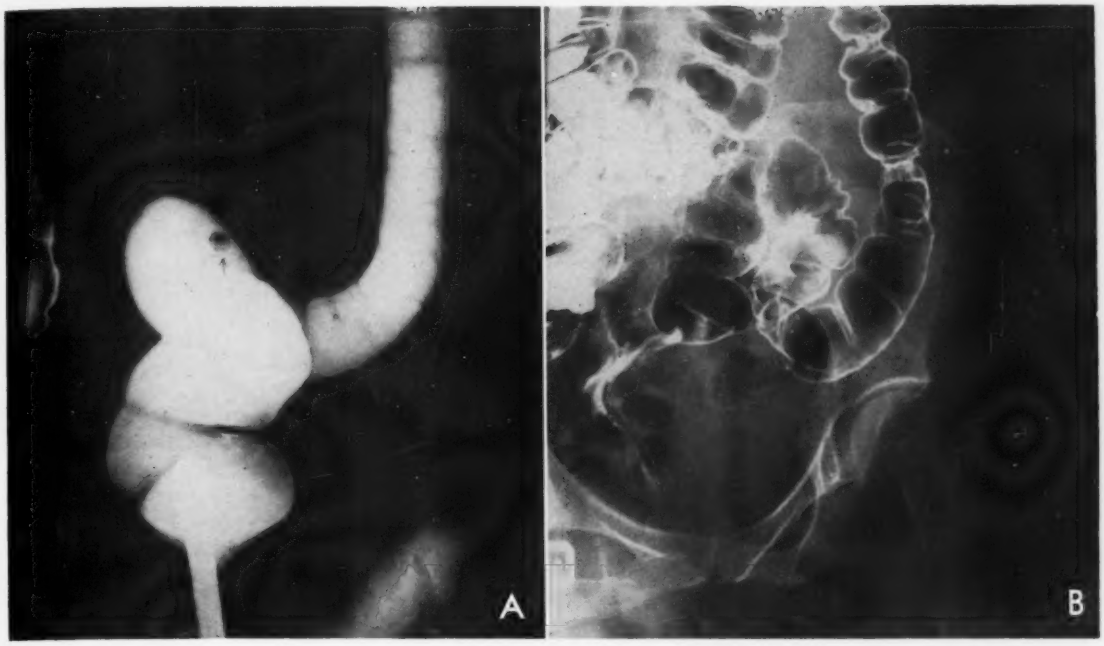

Fig. 7. (*A* and *B*) The polyp removed by the proctologist may not be the one demonstrated by the radiologist. Two previous demonstrations of this lesion resulted in removal of two polyps from the rectum. In each instance, the polyp removed was thought to be the one demonstrated roentgenologically. (*A*) The "cooky cutter" defect was visible fluoroscopically and reproduced on several spot films, some of which showed the pedicle which is here seen in the double contrast study. (*B*) The demonstration on double contrast is impressive, but it could easily be obscured at a slightly different angle.

own investigation he is under the impression that the colon is properly cleansed. Almost invariably a poor roentgenologic examination results since excess air has been introduced by the proctologist and manipulation has caused feces to move into the distal loops of the large intestine. If one has to carry out a study of the colon by barium enema under such conditions, he should be prepared to administer two barium enemas, the first of which acts as a cleansing agent. The colon is filled to the mid-transverse portion with the barium suspension and then the patient is permitted to expel it. The diagnostic barium enema examination is then performed. Gianturco and Miller require a delay of twenty-four hours between proctosigmoidoscopy and a barium enema study. They do perform rectoscopy on the same day but take special precautions to prevent the introduction of air. The preparation they require is clearly superior to that ordinarily demanded by the proctologist.

The Barium Suspension. U.S.P. barium is mixed with water in the proportions of 1:6 by weight. This seems thinner than that employed by Gianturco and Miller who prefer a 1:4 mixture by volume, but anything in this range is quite satisfactory. The statement that these mixtures are thin is misleading, as they are more than adequate

Fig. 6. (*A*, *B*, *C*, *D*, *E*, and *F*) The fluoroscopic image amplifier permits detection of shadows which would probably not be noted by standard fluoroscopy and leads to more conclusive demonstration of lesions. The ring-shaped shadow in Figure 6*A* was clearly visible under the image amplifier and the polyp was immediately outlined by putting patient into Trendelenburg position. Figures 6*C* and 6*E* show polyp in double contrast; Figure 6*D*, polyp and pedicle in profile; Figure 6*F* double shadow of polyp and pedicle superimposed. Figures 6*D* and 6*F* are almost pathognomonic. Figures 6*C* and 6*E* are only confirmatory or need confirmation.

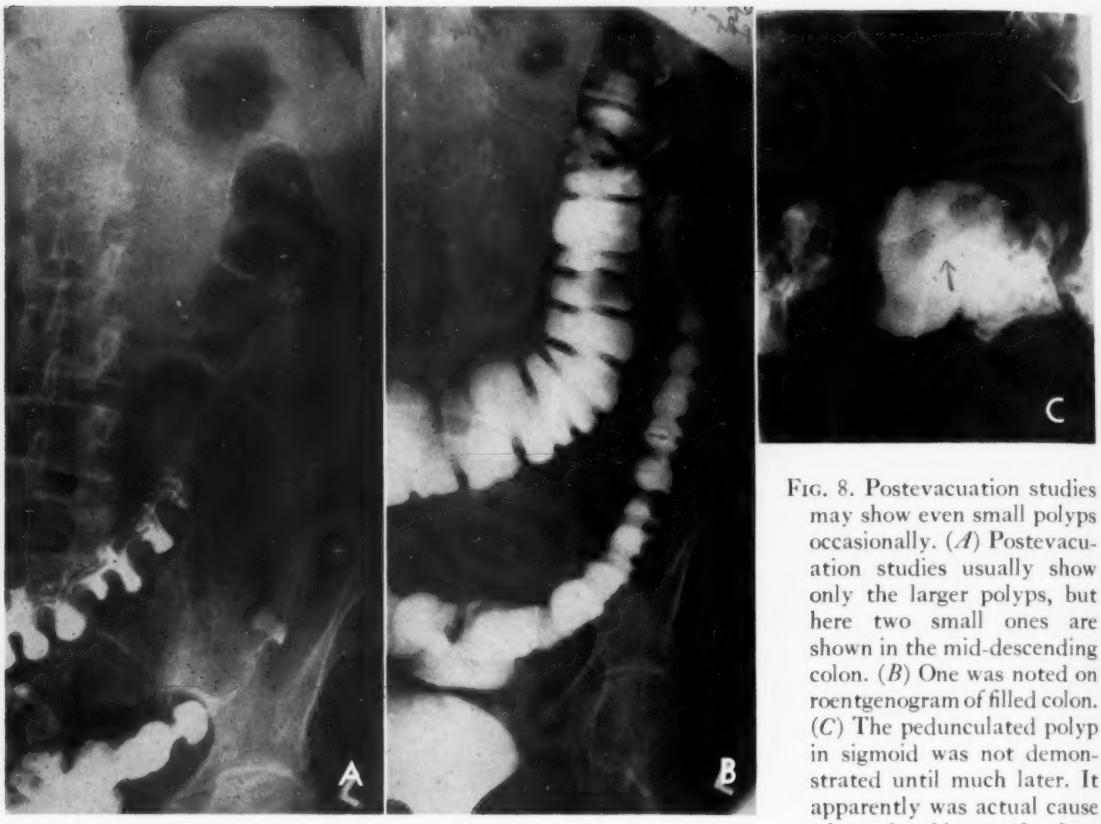

Fig. 8. Postevacuation studies may show even small polyps occasionally. (*A*) Postevacuation studies usually show only the larger polyps, but here two small ones are shown in the mid-descending colon. (*B*) One was noted on roentgenogram of filled colon. (*C*) The pedunculated polyp in sigmoid was not demonstrated until much later. It apparently was actual cause of occasional bouts of melena which did not clear up after the first operation. Large pedunculated polyps are more likely to bleed than small or sessile ones.

for fluoroscopy. They sometimes seem thin because some of the loops are partially filled with retained air. This is particularly true in anteroposterior or anteroposterior-oblique studies of the distal descending and proximal sigmoid regions. Heavier suspensions are so difficult to penetrate by roentgen rays that one may not realize whether or not the loop is completely filled. The actual density should, of course, be adjusted to the exposure factors—roentgens per second, kilovoltage, thickness of the patient, etc. One per cent tannic acid and two tablespoons of methylcellulose jell (methocel 1400 C.P.S. Dow) are added.* This jell is prepared by adding four tablespoons of methocel powder to 240 cc. of hot water, after which 480 cc. of warm water is added. This is allowed to stand overnight or is placed in the refrigerator. The suspension employed is not stable and should be stirred during use. It does seem to yield almost uniformly excellent evacuation patterns, the coating showing little tendency to dry and crack. The tannic acid may be left out if previous information indicates that the colon is unusually irritable, or the examination may be repeated without tannic acid. This suspension is employed for single contrast study only. The method seems to reduce definitely the griping tendencies of the tannic acid.

Very thin suspensions such as those advocated by Potter have not proved successful in the author's experience, although the fundamental principle is the same as in the high kilovoltage technique. Fluoroscopic visibility, always poor, is made even poorer, contrast in the roent-

* For the past year carboxymethylcellulose (high viscosity cellulose gum, Hercules Powder Co.) has replaced methocel. The resulting suspension is more stable.

genograms of the filled colon is decreased, and evacuation studies are often unsatisfactory, the barium failing to stick to the mucous membrane. If preparation is inadequate, excess fluid may be present, diluting the barium suspension further. The polyp, therefore, may be completely hidden in a medium of approximately its own roentgenographic density. This also is a possibility if denser suspensions are employed. Similarly, should the barium settle out in the bowel, the polyp may be hidden in the supernatant liquid, producing no demonstratable defects in the barium column, since there is no contrast between the polyp and the surrounding fluid. Yet the roentgen-ray beam penetrates through exactly the same quantity of barium as if it were in suspension, giving one a false impression. This can, of course, happen with barium suspensions of any density, but the loss of contrast between the polyp and the medium which surrounds it will occur more readily if the suspension is thin. This thin suspension technique is probably best suitable in the cecum, which, because of its size, is often difficult to penetrate adequately.

Potter has acquired great skill with the method of thin suspensions and kilovoltage of ordinary range, as his results indicate. He is quite aware of its pitfalls, taking great care, for example, to leave a large enough interval between the cleansing enema and the barium enema so that excess fluid is absorbed. The method cer-

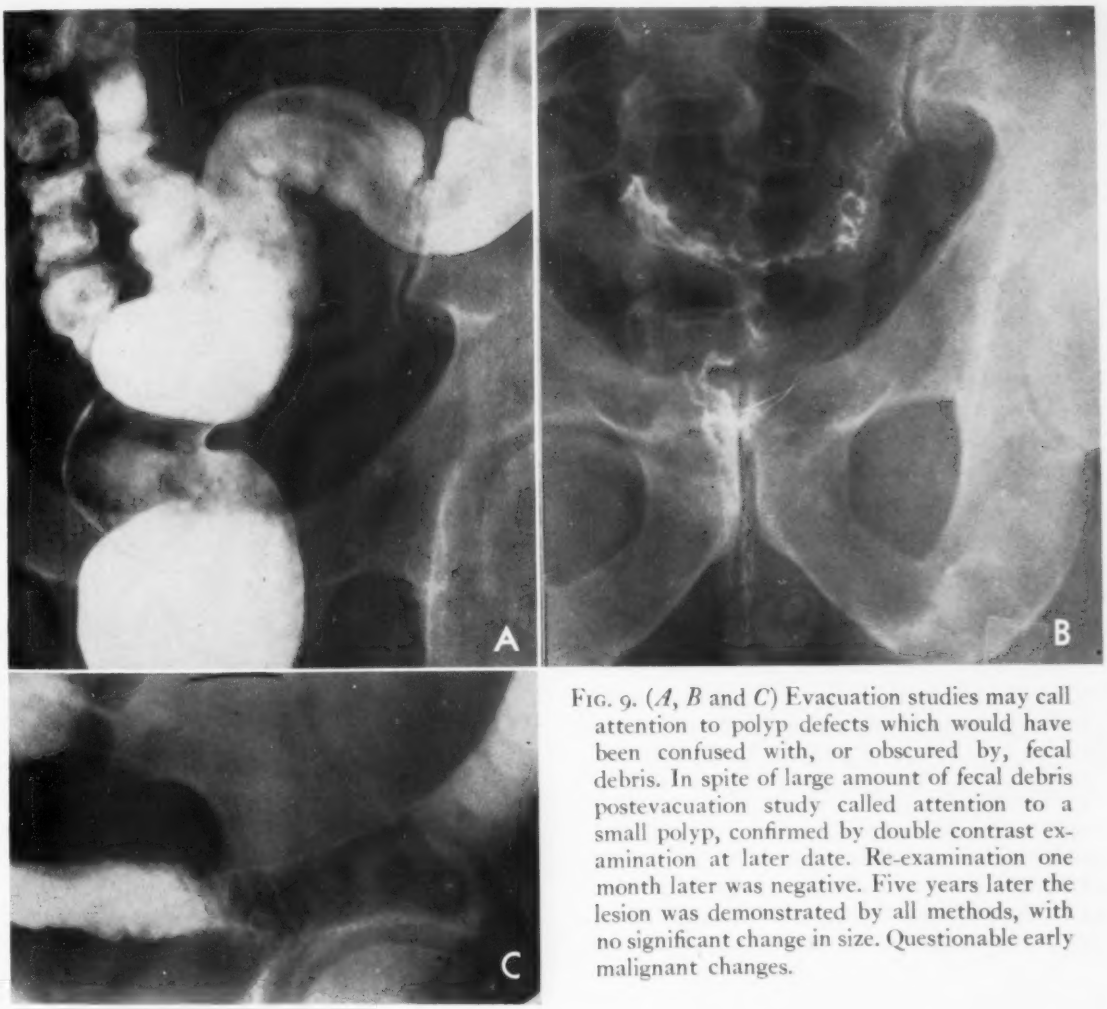

Fig. 9. (*A*, *B* and *C*) Evacuation studies may call attention to polyp defects which would have been confused with, or obscured by, fecal debris. In spite of large amount of fecal debris postevacuation study called attention to a small polyp, confirmed by double contrast examination at later date. Re-examination one month later was negative. Five years later the lesion was demonstrated by all methods, with no significant change in size. Questionable early malignant changes.

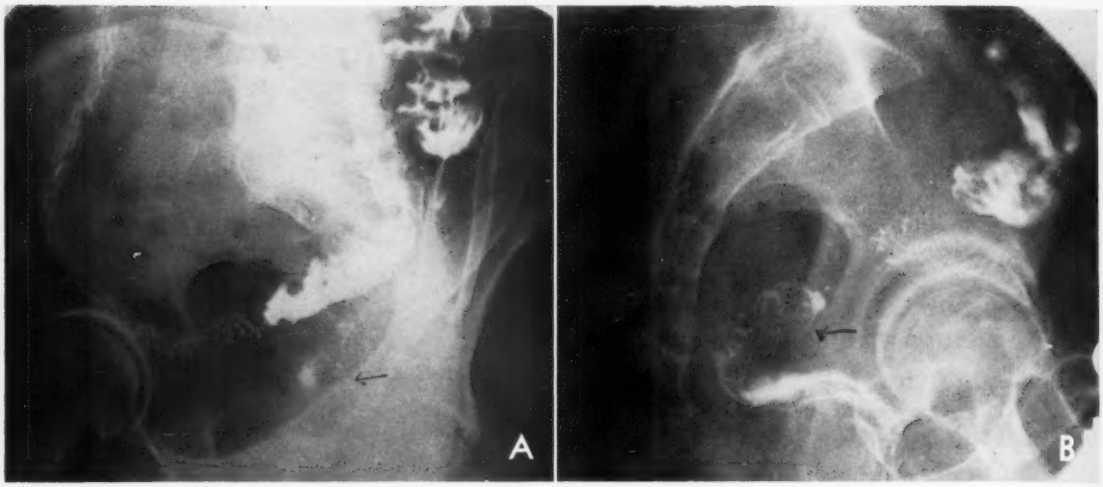

Fig. 10. (*A* and *B*) Large tumor demonstrated on evacuation studies, but proctologist could not find it until after second sigmoidoscopy. If the sigmoid is deep in the pelvis, a sigmoidal polyp may seem to be in the rectosigmoid colon in lateral view.

tainly has advantages over those procedures which seem designed to conceal, rather than reveal, intraluminal detail.

Suction and Controlled Drainage. There are several ways of accomplishing this. The three-way valve box designed by Templeton has given satisfaction for several years. He and Addington[21] have described the advantages of it in some detail. Suction is applied to the evacuation channel by a water siphon which works on the Venturi principle. The "Filordrain" manufactured by Pemberthy is available in almost any hardware store for about two dollars. It is attached to the faucet of a "janitor's sink," works better and is cleaner than evacuation bottles and motor pumps. The waste, which is quite liquid because the holes in the tip of the enema tube will not pass large particles, goes directly down the drain, mixed with water. It is desirable to have the valve which controls the flow of water, and thus the degree of suction, close to the fluoroscopic table. The suction tip should be turned off at the valve box when the tip is inserted or removed, but otherwise there are no great problems, since the tubing collapses before the suction can become too great. Clogging of the enema tip usually can be cleared by introducing a small amount of air with the hand bulb which is attached to the valve box. Crane and several other plumbing manufacturers market compact units specifically designed for siphonage of cavity fluids. These include the faucet, the siphon, and the trap, and can be mounted on the wall. Y tubes and clamps in conjunction with siphonage work moderately well, but they are not as convenient as the somewhat costly Templeton device. Suction usually is not employed to empty the intestine completely as the procedure is too time-consuming and can rarely be satisfactorily accomplished. Excess air and fluid can be removed before the enema is started, and excess barium is removed after the completion of fluoroscopy so that haustral folds are visible. Thus, it is much easier to render the entire colon translucent when roentgenographed. The patient is able to evacuate the enema more completely because there is less to be evacuated, and he is considerably more comfortable during the examination. Inflow and outflow of barium is under direct control of the radiologist.

Standard Fluoroscopy. (This method was replaced by fluoroscopic image amplification about one year ago.) It is carried out at

90 kv., 8 roentgens per second at the table top. Fluoroscopy may reveal suspicious defects requiring further study. It permits the observation of flexibility and other features of the intestinal contour. Sometimes it calls attention to polypoid defects and helps to demonstrate the permanence of a defect. The author does not wish to underestimate fluoroscopy, but he feels that as a means of detecting polyps it has shown decided limitations. On more than one occasion he could not find the lesion by fluoroscopy, even though he had already demonstrated it on the film and knew exactly where to look for it. His optical apparatus is apparently subject to the physiologic and other limitations which were described by Chamberlain in his Carman lecture of 1941 entitled "Fluoroscopes and Fluoroscopy," and also by Morgan. Such limitations would seem reasonable when one considers that an image of 30 per cent contrast must be fifteen times larger to be seen at fluoroscopy of a 20 cm. abdomen than on the roentgenogram.

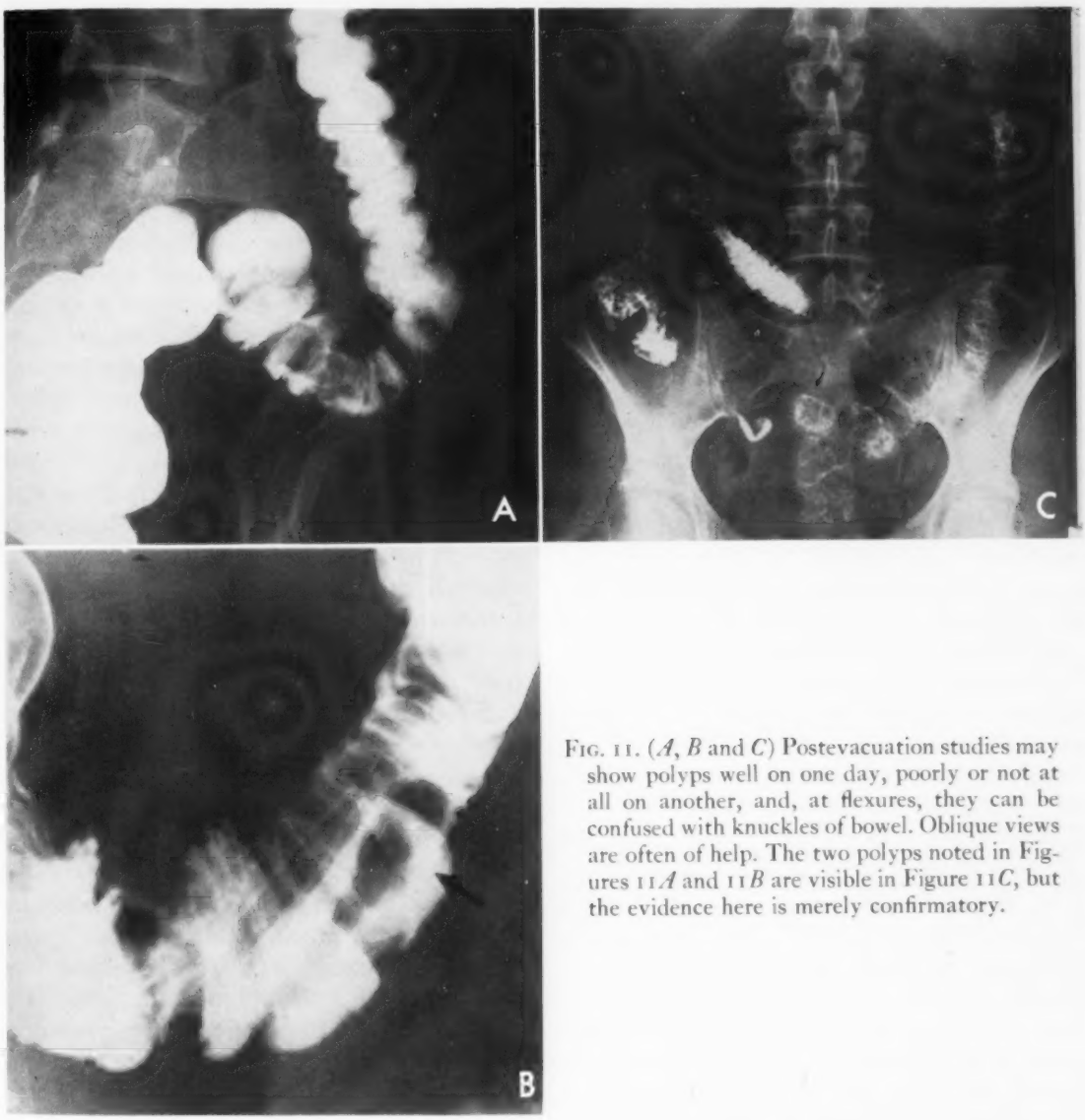

FIG. 11. (*A*, *B* and *C*) Postevacuation studies may show polyps well on one day, poorly or not at all on another, and, at flexures, they can be confused with knuckles of bowel. Oblique views are often of help. The two polyps noted in Figures 11*A* and 11*B* are visible in Figure 11*C*, but the evidence here is merely confirmatory.

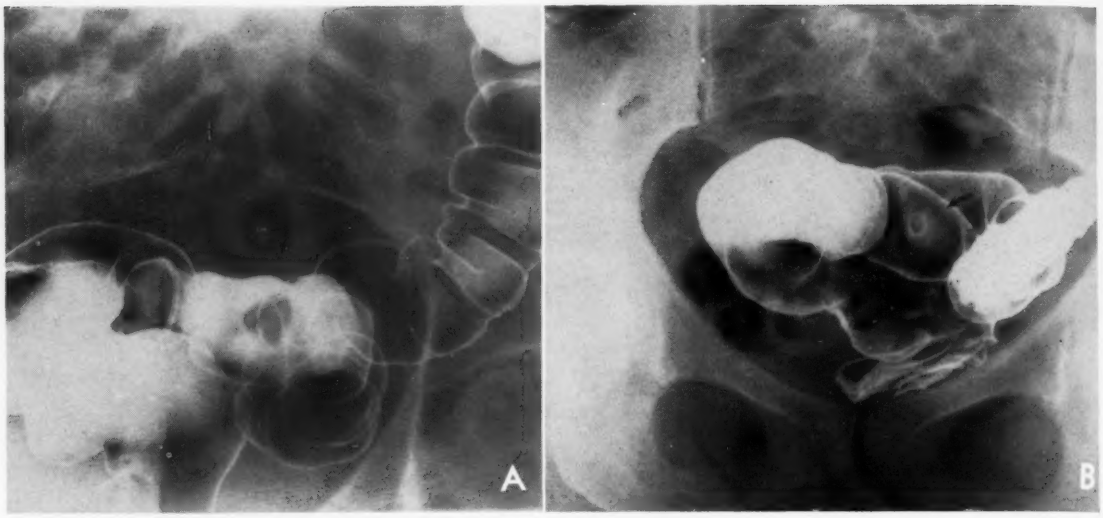

Fig. 12. (*A* and *B*) Double contrast studies often demonstrate polyps as filling defects similar to those shown on a single contrast study rather than as shadows of increased density (polyp coated by barium) projecting into air-distended, barium-coated bowel. The depth of the barium puddle will often determine the degree of visibility of the polyp. Compare with Figure 3*B*. Note "doughnut" in Figure 12*B*—polyp and pedicle superimposed. Comparable phenomenon in single contrast examination. (See Figures 4*B*, 6*F*.)

Fluoroscopy with the Fluoroscopic Image Amplifier. This remarkable instrument is a definite addition to the armamentarium of the radiologist interested in gastrointestinal work. Its cost, bulk, and the small field of view are more than compensated for by its other advantages. *It is almost as superior to standard fluoroscopy as standard fluoroscopy is to no fluoroscopy whatever.* The author does not like the term "image amplifier" because the brilliance of the image, and not its size, is amplified, but this term seems to have been generally adopted. The image brightness is increased approximately 200 times over that of usual fluoroscopy. At the moment the spot film is obtained, milliamperes shift from 3 to 200 and the brilliance of this fluoroscopic image is greatly increased. It is the ideal moment to obtain a bright view, particularly in large patients. It probably justifies replacing metal-strapped cassettes with those having no interfering straps to obscure the image at that moment. The small field has one definite advantage: if the shutters are closed, as they should be so that they show on the edge of the field, scattered radiation and exposure of the patient are markedly reduced. The author does not believe that the image amplifier can replace roentgenography, although it can well be a guide to improving one's roentgenographic technique. On several occasions the image amplifier has permitted detection of defects so faint that they might have been overlooked or disregarded otherwise. It has also helped to demonstrate the origin of defects not produced by polyps. Furthermore, the author is now able to see fluoroscopically the defects produced by polyps in air contrast studies more often, and thus obtains a better objective demonstration of these lesions. He has, however, sometimes been barely able to detect by the image amplifier the site of the lesion which he has already demonstrated by spot films and was again able to demonstrate by additional subsequent films. A few times he has missed the lesion with the image amplifier at first examination, although it was seen clearly on re-examination, after review of the wet films had indicated its presence. This was no doubt due to a lapse in attention, or generally in examining an area where one would ordinarily not expect to

see a polyp, as in the transverse colon. Any fluoroscope is a highly subjective device. The fluoroscope, even when its brightness is amplified 200 times (considerably more at the moment when the spot films are obtained), is still only the "moving finger" while the films are the "indelible writing," which does not disappear the moment one removes the pencil from the paper and which does offer objective proof of the diagnosis. It should also be remembered that fluoroscopic settings are rather fixed, *e.g.*, 3 ma., 90 kv., 1/25 second (the time which it takes the eye to accept and reject the image), and are not readily variable for patient thickness. Neither is 90 kv. as penetrating as the 110–120 kv. employed for high kilovoltage roentgenography.

Spot Films of the Sigmoid and Distal Portion of the Descending Colon. These are generally obtained at 90 kv., with the phototimer set to give dark roentgenograms. By routinely spot filming the sigmoid and the distal portion of the descending colon with compression at optimal angles, making about eight 4×5 inch spot exposures on two 8×10 inch films, the author had been able to demonstrate a considerable number of unsuspected polypoid tumors in addition to those he suspected even before he added the high kilovoltage technique to his procedure. *Eight 4×5 inch or smaller spot exposures on two 8×10 inch cassettes scatter less radiation than one 8×10 inch spot film exposure and yield much more information.*

Oblique Roentgenograms of the Distal Colon. For this examination the flow of barium is stopped as soon as it has reached the descending colon and the patient is rolled on his left side until the loops are best revealed. One or sometimes two 10×12 inch roentgenograms are taken with 100–120 kv. and appropriate milliampere second exposure. The high kilovoltage flattens out the contrast between the loops of the colon so that they are demonstrated at fairly uniform density, one loop seen through another where they overlap. If the patient is quite thin, 70 kv. may be sufficient, but if he is thick, 120 kv. may not be enough, and certainly 120 kv. is not enough if total exposure is inadequate.

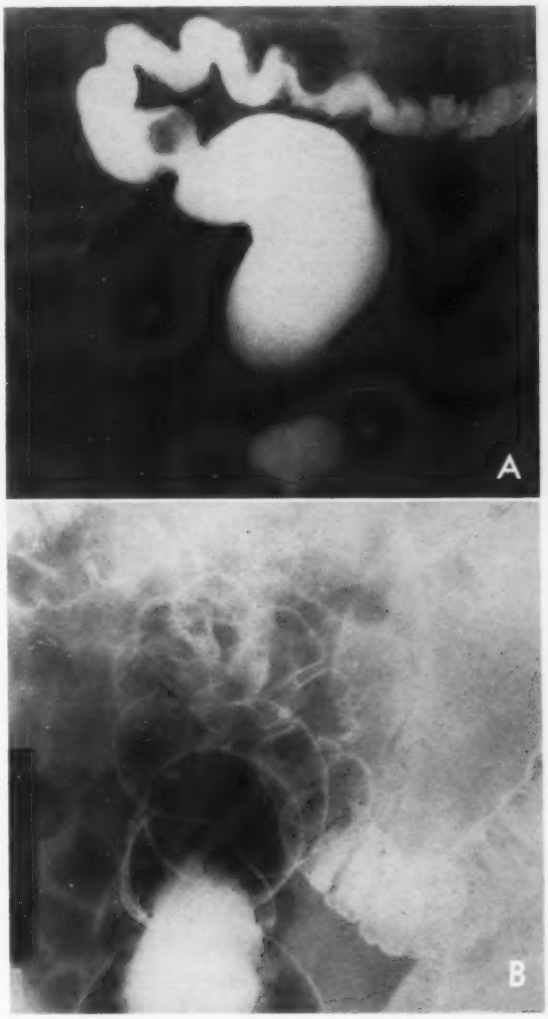

FIG. 13. (*A* and *B*) Although the polyp is demonstrated by double contrast, note how it is obscured by air-distended, overlapping intestinal loops.

After the roentgenogram in the oblique view is obtained, one can proceed with the filling of the remainder of the colon. Thus, there is not the usual hazard of the filled bowel obscuring the sigmoid in the oblique views. Another advantage of these oblique views certainly accounts for some of the success of Gianturco and Miller. While these oblique views are being ob-

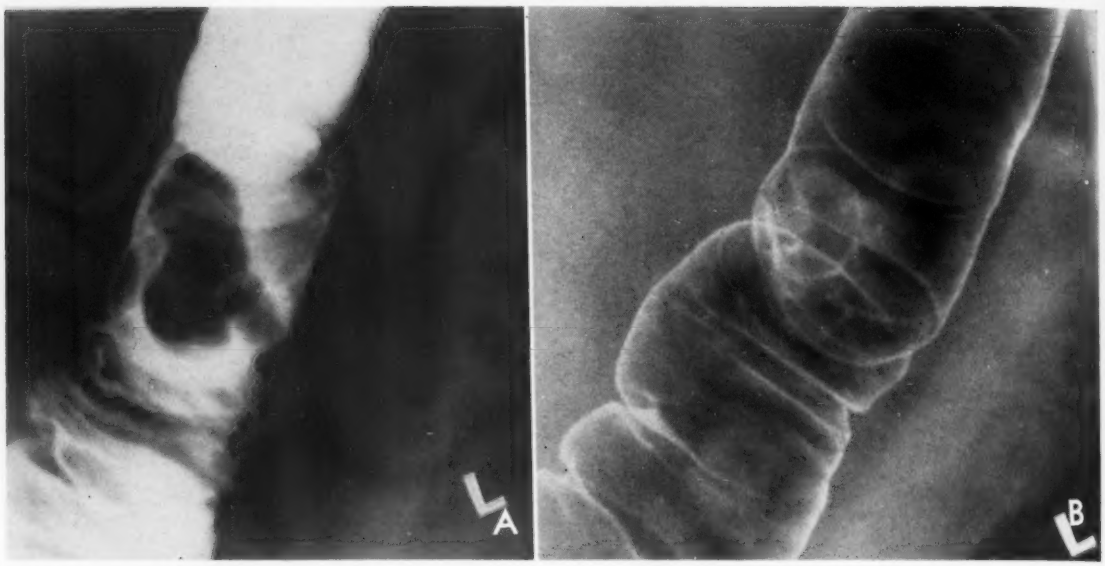

Fig. 14. (*A* and *B*) A large polyp may sometimes be more convincingly demonstrated by single contrast study, even when the double contrast examination seems technically satisfactory and there are no overlapping intestinal loops.

tained and before fluoroscopy is resumed, the barium continues to move gradually by its own weight to the splenic flexure or beyond. The colon is "open above," therefore, it is not necessary to add much barium to fill the remainder of the colon and the latter becomes only moderately distended. Because of this, it is easier to obtain the desired translucency of the bowel and intraluminal shadows will be more readily demonstrated. (The anteroposterior oblique view is subject to the criticism mentioned below and perhaps a posteroanterior oblique roentgenogram might be of more value, but it does not lend itself so readily to routine examination.)

Posteroanterior and Anteroposterior Roentgenograms of the Filled Colon. These are obtained with maximal penetration, generally at 120 kv. peak, 60 ma., 40 inch distance, 16:1 Bucky grid. The shift of position from anteroposterior to posteroanterior re-distributes fecal debris, barium and air. This is particularly important at the juncture of the descending colon and sigmoid, where many polyps are located. This region is uppermost in the anteroposterior view; hence, barium may be present only on the floor of the loop, since air almost always is present in the intestine. The barium flows over the floor of the loop. A polyp may lie in the air pocket above and may not be demonstrated unless it should fall, or be directed into, a pool of barium. Even when air does not collect here, this loop may not distend completely, so that the criss-cross pattern of the partially evacuated colon obscures the lesion. When the patient's position is reversed, the entire loop is filled and the defect produced by the polyp may be shown then. This seems to be one of the reasons why spot films of this region taken in the anteroposterior and anteroposterior oblique position may not show the lesion, but posteroanterior roentgenograms of the filled colon may do so. During fluoroscopy, Trendelenburg position may be required and the patient should be turned on the abdomen at some time to fill this and similar loops.

Loops of bowel, particularly in the sigmoid area, will change their relationship with these shifts and also between examinations, even when these are performed

within minutes of each other. This is another factor which makes the lesion obvious at one examination and obscured at the next. Furthermore, a long pedicle permits considerable shift in the position of a polyp between views.

The Position of Chassard-Lapiné. This "sitting" position of Chassard-Lapiné (1923) most recently recommended by Ettinger and others for studies of the lower colon for cancer and inflammatory lesions, and by Moreton[11] to demonstrate the sigmoid loops in the double contrast study, has a definite value. In some instances it enables demonstration of a polyp quite well. In fact, since it uncoils an additional loop of bowel in a manner which cannot be accomplished in any other way, it is excellent for studying the sigmoid for any lesion. But here again, penetration must be adequate.

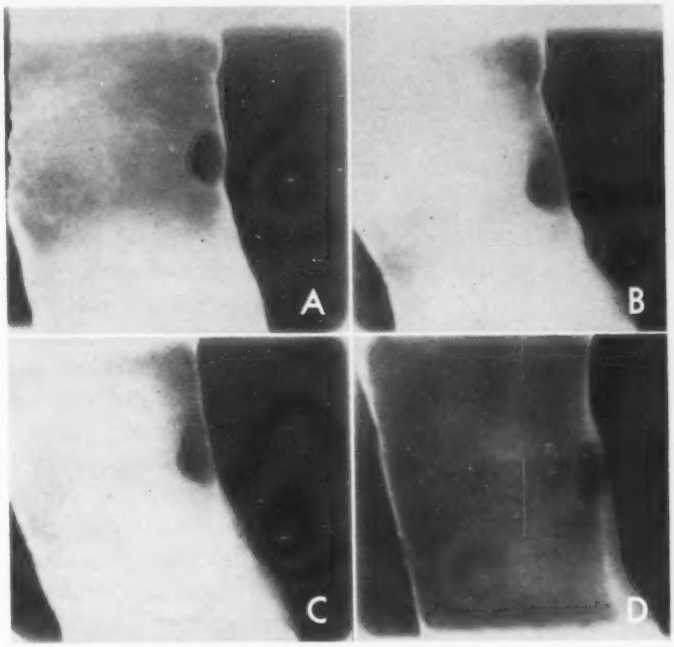

Fig. 15. (*A*, *B*, *C* and *D*) By tilting and rolling the patient, the polypoid origin of this small shadow was demonstrated in the double contrast study. (A diverticulum should fill with barium and/or project to the periphery of the bowel.)

Postevacuation Study. As noted, the barium suspension contains tannic acid and methylcellulose to improve the post-evacuation pattern. The patient is allowed to evacuate, then a 14×17 inch postero-anterior, a 10×12 inch anteroposterior oblique sigmoid and a lateral rectosigmoid roentgenogram are obtained. This examination gives information about the colon in general. It is also important because fecal material, otherwise difficult to distinguish from polyps, will be expelled. As already mentioned, if fecal debris is present, evacuation of a preliminary barium enema carried to the transverse colon often serves as the best cleansing enema. Sometimes a defect which, because of the presence of fecal debris, is also thought to be produced by feces will demonstrate itself as a bulge in the colon, indicating that it is probably a polyp, since such bulges are not common around feces. There is general agreement that evacuation study is of value only for lesions larger than 1 cm., but occasionally quite small tumors, 3 or 4 mm. in diameter, will be demonstrated either as small bulges or as fine rings which

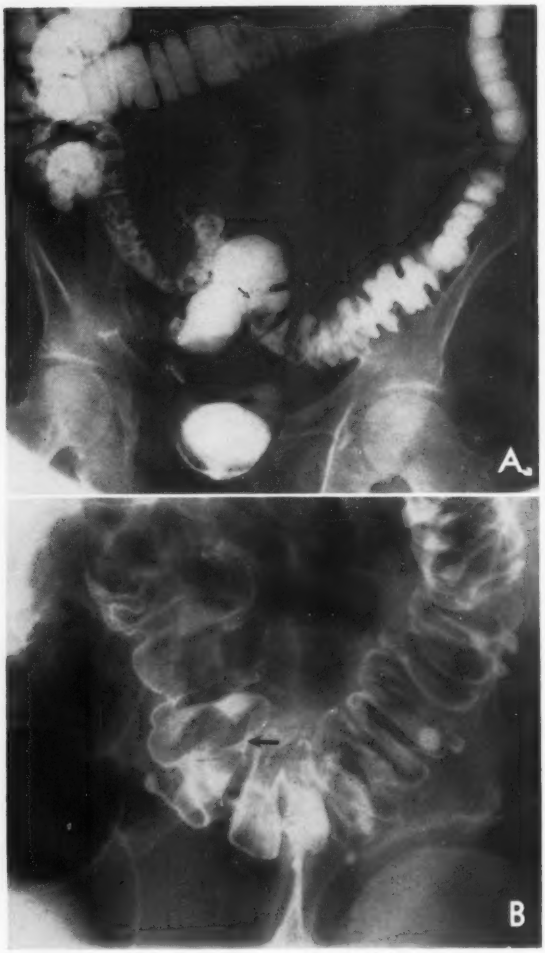

Fig. 16. (*A* and *B*) The bleeding often ascribed to diverticulitis is not infrequently caused by polyposis. The bleeding in this case was ascribed to diverticulitis for years. Note that the polyp in Figure 16*B* is shown as a filling defect (see Figure 12*A*) in a shallow layer of barium, not as a coated structure projecting into distended bowel. (See Figures 7*B*, 12*B*, and 13*B*.)

call for additional investigation. In the lateral roentgenogram of the evacuated rectosigmoid, large polyps, which could be easily detected by the finger or by sigmoidoscopy, are sometimes seen but because the tumors were asymptomatic, those examinations had not been performed. The post-evacuation study is of limited usefulness at the junctions of the descending colon and sigmoid, and the sigmoid and rectosigmoid, because here the collapsed loops tend to overlap, and the pattern produced is indistinguishable from that of a polyp or vice versa. Unfortunately many polyps lie in this area. The oblique view is of help in clarifying these regions. Too often the barium will pass completely by a polyp so that the defect has disappeared and therefore was erroneously presumed to be produced by feces, air, etc.

Double Contrast Study. The author employs the double contrast technique described by Jones, Kaplan, and Windholz,[11] and takes anteroposterior and posteroanterior roentgenograms, as well as roentgenograms in the "sitting" position as recommended by Moreton. At one time he used baridol, and now generally employs barotrast or bariloid. All seem to be satisfactory. Bariloid is the easiest to mix.

The following roentgenograms are obtained: 14×17 inch anteroposterior and posteroanterior roentgenograms with tube overhead, after which the tube is shifted so the roentgen-ray beam will be horizontal across the table, and right lateral and left lateral decubitus roentgenograms are taken using a Lysholm cross-hatched grid; a posteroanterior roentgenogram in the upright position; a lateral roentgenogram of the rectosigmoid colon; an oblique roentgenogram of the sigmoid colon; and, finally, a roentgenogram in the Chassard-Lapiné "sitting" position completes the study.

This procedure usually confirms the presence of lesions already demonstrated and may reveal the presence of others which may have been overlooked, or may demonstrate lesions which the single contrast method failed, for one reason or another, to show. Such is the case often enough to warrant retention of the double contrast study as a part of the complete study for polyposis. Not infrequently, however, the method fails to demonstrate even larger obvious lesions. Sometimes this is due to technical difficulties, but even when the roentgenograms seem more than satisfactory the lesion may not be well shown, if shown at all. A phenomenon similar to that which the author has noted

Table I

BARIUM ENEMA TECHNIQUES

For Average Patients

Positions	Ma.	Seconds	Distance (Inches)	Kvp.	Grid
		Before Evacuation			
Oblique anteroposterior	200	0.4	40	120	16:1 Bucky
Anteroposterior	200	0.3	40	120	16:1 Bucky
Posteroanterior	200	0.3	40	115	16:1 Bucky
Lateral	200	2.0	40	120	16:1 Bucky
Chassard-Lapiné	200	1.25	40	120	16:1 Bucky
		After Evacuation			
Oblique anteroposterior	200	0.4	40	110	16:1 Bucky
Posteroanterior	200	0.3	40	2× cm. and 40	16:1 Bucky
Lateral	200	2.0	40	100	16:1 Bucky

in gallbladder studies seems to account for this in part. If a gallbladder contains opaque medium of the usual density, the thin calcium ring of a gallstone may not be visible because it is of about the same density as the surrounding medium. Similarly, a polyp with its coating of barium may rest in a thin puddle of just sufficient density to obliterate the outline of the tumor. Barium in an overlapping loop may obscure contrast in a like manner.

Often a tumor may be demonstrated on only one view of the double contrast study. If one therefore relied on the air contrast study for all of his information concerning the presence or absence of polyps, he would be faced with repeating it for confirmation, always a considerable undertaking, without assurance that he would even be able to reproduce the defect a second time. For this reason, unless symptoms are present, one hesitates to carry out a re-check examination. Reproduction of a defect by single contrast methods is obviously much simpler—a refilling of the area in question, usually just the distal colon, and a few fluoroscopically aimed (or even blind) spot films.

If a probable lesion has already been demonstrated by single contrast examination, the double contrast study is performed, usually about two or three days later, rarely on the same day. This is also done if there is a history of bleeding or if findings at sigmoidoscopy indicate the possible presence of a polyp higher up, even if it has not been demonstrated by the single contrast study already per-

Table II

AIR CONTRAST STUDY

Positions	Ma.	Seconds	Distance (Inches)	Kvp.	Grid
Right and left decubitus	200	0.3	40	85	Lysholm crosshatch
Posteroanterior	200	0.3	40	95	16:1 Bucky
Anteroposterior	200	0.3	40	100	16:1 Bucky
Posteroanterior, upright	200	0.3	40	110	16:1 Bucky
Lateral	200	2.5	40	110	16:1 Bucky
Oblique	200	0.3	40	110	16:1 Bucky

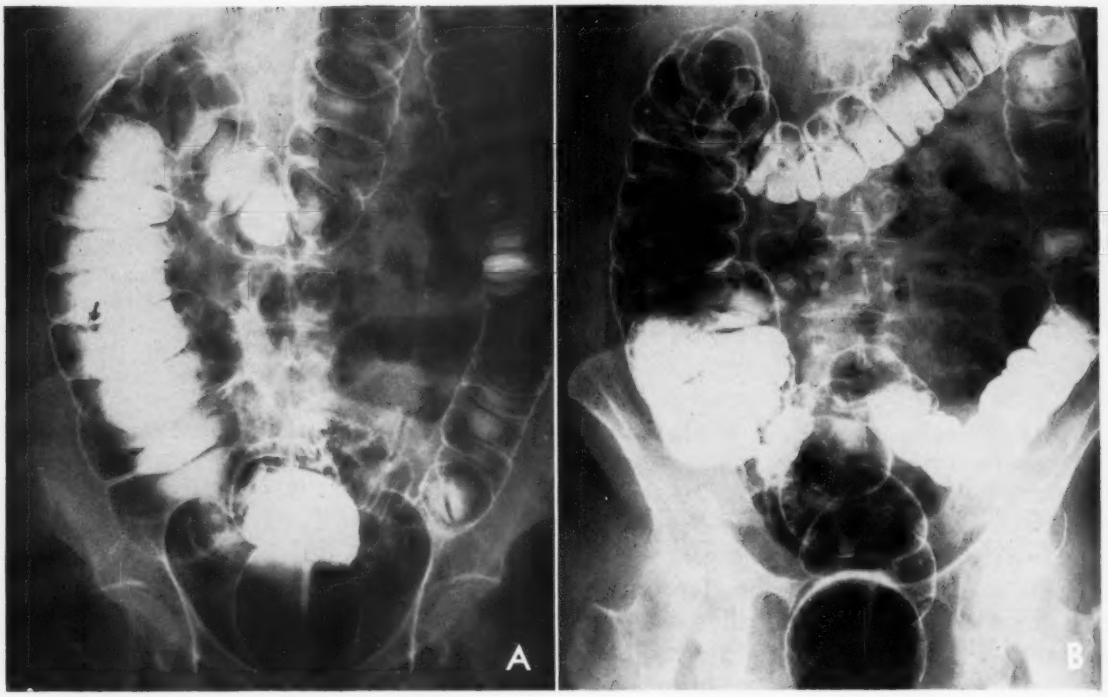

Fig. 17. (*A* and *B*) In cecum and rectum double contrast study seems more successful than other roentgenologic methods. Small polyp in ascending colon. Previous cancer of distal descending colon. Occasional bleeding. Detected only by double contrast examination. Note "doughnut"—polyp and pedicle superimposed in Figure 17*B*. (Compare with Figure 12*B*.) Three previous single and double contrast studies were negative. Bleeding ceased after removal of this small pedunculated lesion.

formed. The double contrast study may show the lesion as a defect of slightly greater density projecting into the highly transparent, air-distended, barium-coated loops or, not infrequently, as a sharply defined defect in a puddle of barium—ideally demonstrated, one might say, since there is very little or no obscuring barium above or below the lesion to diminish contrast. For this reason the author over-penetrates the anteroposterior and posteroanterior air contrast roentgenograms. The blackening of the film forces him to study it inch by inch with a spotlight. On the single contrast film the lesion is black against more or less homogeneous white; on the double contrast roentgenograms it is often one shade of gray against another with a background of confusing shadows, unless care is exercised.

The prior demonstration of the polyp by single contrast examination permits one to know just where to look in the air contrast study and considerably improves one's diagnostic acumen.

The use of the double contrast study also gives one an opportunity to re-check the area in question by fluoroscopy and spot films *before* the air is introduced. More often than not this produces the most satisfactory confirmatory evidence, since the defect is shown in the same location, on several films, in several different aspects, and its appearance is directly comparable to that on the roentgenograms obtained at the first examination.

The author does not believe that a pool of barium should remain in the intestine so it can be used to keep the coating moist. In theory these puddles are shifted about with change in position, but often they leave large blind areas, particularly in the sigmoid and rectosigmoid colon. An attempt should be made to evacuate excess barium

from the lower intestine by siphonage and manipulation of the patient, but it may be just as expeditious to carry the barium almost to the hepatic flexure, then to allow the patient to evacuate the barium. Air can be injected after the barium is evacuated or both procedures may be combined. In this way polyps in the sigmoid, rectosigmoid, or lower sigmoid which would otherwise be obscured by pools of barium can be demonstrated. The newer "colloidal" preparations, particularly barotrast and bariloid seem especially resistant to cracking and "alligatoring" so that the patient has time to empty the colon fairly completely. If the cecum does not become coated, additional barium can be introduced and forced through the cecum by air injected behind it. This is usually easier than introducing the additional barium after distending the intestine with air.

Sometimes polyps can be seen in *single* air contrast roentgenograms just as one shows a brain tumor projecting into the air-filled ventricles. In the days when ordinary barium and water mixtures were employed, large areas of the intestine would not be coated, yet the polyp would be visible projecting into the air-filled lumen. This is sometimes true even now, and one should keep this possibility in mind.

Fig. 18. Double contrast is probably the best way of showing roentgenologically small polyps in the rectum, if there is no excess barium present.

It is not the intention of the author to detract from the value of the double contrast method, but he is at times almost inclined to agree with Bell and Douglas, who stated: "The double contrast method is not highly accurate and is beset with many difficulties and possible sources of error, even in the hands of the most painstaking, the most highly trained, and most experienced examiner. It is of help, however, when its values and limitations are recognized." This was written in 1948. To some degree the criticism applies today, especially if one's double contrast study has not kept pace with improvements in technique.

Proctoscopy and Sigmoidoscopy. At least 60 per cent of all polyps of the large intestine are within reach of the finger, the proctoscope or the sigmoidoscope. If proctosigmoidoscopy were performed routinely in every patient over fifty years of age, the incidence of carcinoma of the lower colon would be reduced much more than by any improvement in our roentgenologic methods. The author, therefore, favors routine rectoscopy and sigmoidoscopy in the older patient before the barium enema study is performed. This may often be more easily performed by the referring physician or proctologist than by the radiologist.

Multiple Polyps. Potter has called attention to the fact that 30 to 40 per cent of polyps are multiple. The radiologist may find a polyp on one occasion and, in attempting to confirm it, discover another. A double contrast study may show still another polyp, and the surgeon may find one that has been previously overlooked. On several occasions the author has demonstrated polyps in the distal sigmoid and recommended sigmoidoscopy for confirmation. A polyp would be found and removed, but re-examination by barium enema at a

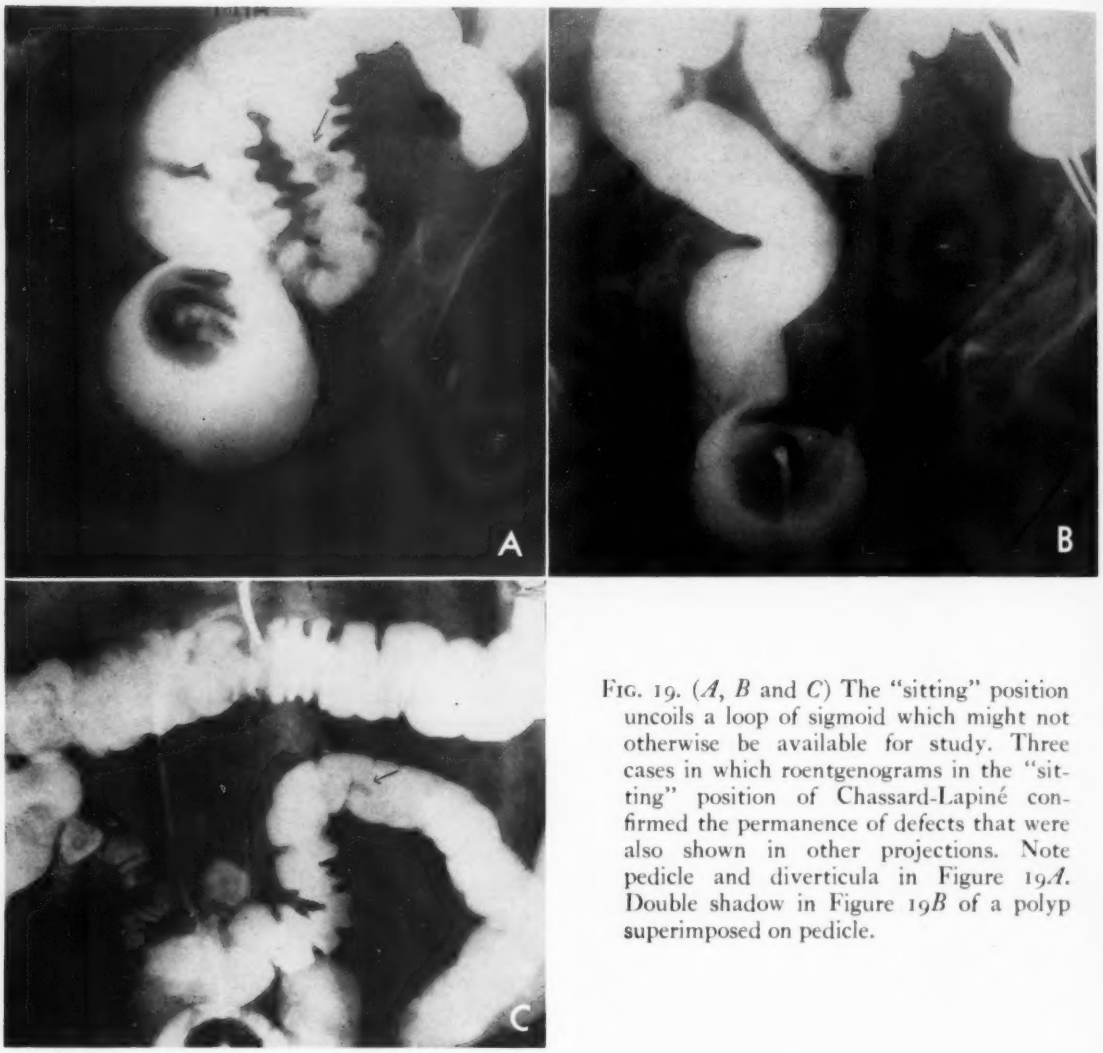

Fig. 19. (*A*, *B* and *C*) The "sitting" position uncoils a loop of sigmoid which might not otherwise be available for study. Three cases in which roentgenograms in the "sitting" position of Chassard-Lapiné confirmed the permanence of defects that were also shown in other projections. Note pedicle and diverticula in Figure 19*A*. Double shadow in Figure 19*B* of a polyp superimposed on pedicle.

later date would show that the original polyp still remained. Likewise, one must not overlook the possibility that the small round shadow resembling a diverticulum or air bubble, or even fecal debris, in the double contrast study may be produced by a small polyp, although one has already confirmed the presence of a more obvious, or previously suspected tumor.

The Association of Diverticulitis and Polyposis. There is no satisfactory evidence that cancer of the large intestine or polyposis is more common in the presence of diverticulitis. These lesions are found together because the patients are in similar age groups. Bleeding apparently can occur as a result of diverticulitis, but bleeding should not be ascribed to diverticulitis merely because there is evidence of the latter. Careful re-examination of patients whose melana has for many years been ascribed to diverticulitis will often enough result in the detection of the actual cause—a polyp.

DIFFERENTIAL DIAGNOSIS

A polyp produces a persistent localized filling defect in the barium column. Demonstrating that it is persistent is not always simple. Fecal debris, air, and oil bubbles are frequent problems. Cross-checking often is required. A high "index of

suspicion" leads to the demonstration of unsuspected polyps. This in turn gives one the experience which renders the differential diagnosis more certain. It is often desirable that the colon be re-studied immediately after evacuation of the enema to determine whether the defect persists. If this is not possible, the re-examination may be carried out later in conjunction with the double contrast study.

Gianturco and Miller have aptly compared the demonstration of polyps by the single contrast over-penetration method to the demonstration of nonopaque stones of the gallbladder by cholecystography. The opaque medium must be of adequate density and well-penetrated, yet contrast must be retained between the calculus and the surrounding opaque substance. All radiologists have had the experience of detecting small intraluminal tumors of the gallbladder only on study after the fat meal, for then there is better contrast between the minute lesion and the surrounding material.

In a thin watery contrast medium, the lesion usually is not visible. Neither will a contrast medium that is too dense, of relatively great cross-section, or relatively underexposed, visualize the lesion. By analogy, one must acknowledge that not all polyps can be shown by the single contrast method. Still, it is interesting to note how often small polyps no more than a few millimeters in diameter present themselves as sharply defined, smooth, punched-out defects, as though produced with a cooky cutter, standing out in a barium column of considerable density. The distal colon is often cleansed enough so that the polyp appears as a solitary defect in the otherwise homogeneous barium column. There may be a break in the contour of the intestinal wall due to the attachment of the polyp or a short pedicle. Demonstration of a characteristic long pedicle is not uncommon. The polyp may even change position between exposures due to the length of the pedicle, thus becoming more or less readily demonstrable. Not infrequently the polypoid defect shows as a shadow of double density, the center darker than the periphery. This center represents the shadow of the pedicle and superimposed polyp; the remainder of the shadow represents the rest of the polyp, resembling the doughnut appearance some polyps show in double contrast. Sometimes what seems to be a minute polyp in one view turns out to be a moderately large polyp in another view. The defect visualized in the first view may represent the summation of the shadow of the pedicle and superimposed polyp. The peripheral portion of the polyp is obscured by the surrounding barium. There is often a bend in the colon at the rectosigmoid junction which may strongly resemble a polyp. Also, the tip of the enema catheter can produce a pseudopolypoid defect.

In the double contrast study feces, diverticula, oil, and air bubbles offer the greatest problems. Sometimes it is possible to project diverticula to the periphery of the bowel. A small nonpedunculated polyp resembling the diverticulum changes in form to an ellipse as the patient is rotated to bring it to the edge of the lumen, but will not be projected beyond it. This is, of course, easier to demonstrate when the fluoroscopic image amplifier is employed. A small polyp with a ring of barium around it usually shows this ring to be of uniform width, as though drawn with a pencil, but often air bubbles and diverticula have the same appearance. An air bubble usually has a characteristic fading margin, while feces are often mottled and irregular. The rim of a diverticulum is more likely to be of uneven width, often signet-shaped. A straight or curved fluid level may be shown with changes in position, or the diverticulum may even fill completely. Sometimes the question can be settled under fluoroscopic control by tilting the patient during the double contrast study. The barium then can often be made to fill the diverticulum partially or completely, but it will only accentuate the filling defect produced by a polyp as barium collects

about it. However, differentiation sometimes may be impossible, especially when small polyps are obscured by inflammatory changes of diverticulitis and the overlapping shadows of diverticula.

SUMMARY AND CONCLUSIONS

In recent years many radiologists, in the hope that they could discover smaller and earlier lesions of the colon, have attempted to perfect techniques of examining the large intestine. It has seemed evident that the problem of reducing the mortality due to cancer of the colon and rectum, now responsible for 17 per cent of all deaths from cancer, is closely linked to the detection and eradication of the polyp, which is apparently the precursor of the malignant lesion.

Like many others, the author has tried various combinations of the numerous techniques which have been recommended to best demonstrate these tumors. He now relies principally on a single contrast barium enema study, in which the barium column is made translucent by high kilovoltage exposure, controlled siphonage, and extensive use of spot films made with compression. This is supplemented by examination in special views and by "tannic acid" postevacuation studies. Fundamentally, the procedure is an elaboration of the technique developed by Gianturco and Miller.

This single contrast examination has proved to be excellent, not only as the primary procedure in the demonstration of polyps, but as a routine barium enema study. It, therefore, succeeds in demonstrating many polyps, large and small, which would otherwise not be discovered because they produced no symptoms.

Double contrast study has proved valuable principally as a supplementary or confirmatory procedure. It seems to be more subject to technical difficulties and less reliable than the single contrast study which is advocated. The double contrast study preferred is essentially a combination of the method described by Jones, Kaplan, and Windholz,[10] and that of Moreton.[11]

For the past year the author has had the opportunity of testing the advantages of electronic fluoroscopic image amplification. At the present stage of development it still has many of the limitations of standard fluoroscopy, yet it is almost as much superior to today's standard fluoroscopy as the latter is to none at all. Unfortunately, although it makes the image many times brighter, it does not make the fluoroscopist brighter in proportion.

The author has concluded that there are unavoidable pitfalls in any of the methods outlined here. The procedure which works well on one day will not work well on another. A combination of techniques often is required.

Essential elements in assuring moderate success in finding these lesions of the colon, especially when they are asymptomatic or small, are:

1. Adequate cleansing of the intestine.
2. The realization that polyps of the colon are relatively common.
3. The earnest conviction on the part of the examiner that it is important to find them and, therefore, that they should be searched for routinely.
4. Paying special attention to the distal third of the colon in elderly patients. Seventy per cent of the polyps are located in the distal portion of the large intestine, and 15 per cent of patients over fifty-five years of age have polyps in the colon and rectum.

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DIVERTICULOSIS AND DIVERTICULITIS: ROENTGEN FINDINGS AND THEIR INTERPRETATION

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AT THE turn of the century, it was realized by surgeons and pathologists[9] that diverticula of the colon were quite common after the age of forty-five. For many years, diverticula had been overlooked in routine pathologic examinations and the associated inflammatory changes had been interpreted as a nonspecific sigmoiditis. Basic contributions to the roentgen appearance of diverticulosis and diverticulitis were made by Spriggs and Marxer,[8] George and Leonard,[3] Carman[1] and Case.[2] These authors described in detail the appearance of diverticula, the changes in the configuration of the bowel associated with the presence of a large number of diverticula-diverticulosis, and the appearance when inflammatory changes were superimposed—diverticulitis. George and Leonard[3] emphasized a peculiar serrated appearance of the colon which they believed was almost pathognomonic of chronic diverticulitis. As Case[2] pointed out, however, their description of small serrations close together giving a saw-tooth appearance appeared similar to the "prediverticulosis" of Spriggs and Marxer. At any rate, a serrated, sawtooth or picket-fence deformity of a segment of bowel, most usually the sigmoid, showing numerous diverticula and evidence of spasm was accepted as the most characteristic picture of diverticulitis in textbooks of roentgenologic diagnosis.[7] However, as pointed out recently by Goulard and Hampton,[5] there has been considerable discrepancy between the roentgen impressions of the presence of diverticulitis and clinical findings. It seemed, therefore, desirable to re-examine the roentgen findings in patients with active inflammatory changes due to diverticulitis as indicated by their clinical course.

It is well known that the most common finding on routine barium enema examinations in the older age groups is the presence of diverticula. It is unlikely that a few scattered diverticula are the cause of significant symptoms. However, there is a large group of cases where diverticula are numerous and lead to marked irregular weakening of the wall of the bowel, particularly of the sigmoid. It is likely that most of these patients have symptoms attributable to functional changes associated with this anatomic weakness. Willard and Bockus[11] believe that symptoms are present in about 75 per cent of these individuals if a careful history is taken. These symptoms consist of flatulence, bouts of slight abdominal distress and irregular bowel habits, often following the ingestion of large amounts of roughage or excessive physical exertion. The clinical diagnosis of acute diverticulitis, however, is not made unless there is an attack or an episode of pain associated with signs of a significant local inflammatory process, namely local deep tenderness, occasionally with rebound tenderness, usually in the left lower quadrant, fever, leukocytosis and frequently a palpable mass which changes rapidly in size. Clinically, the diagnosis of chronic diverticulitis is made when there is a history of such episodes and it is suspected that a chronic sinus tract or a chronic fibrosing process or a chronic abscess has resulted from previous acute inflammation. The diagnosis of chronic diverticulitis in the absence of a history of previous acute episodes is difficult on purely clinical grounds. It is likely that acute

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episodes of minor character may be associated with such minimal symptoms and signs that the clinical diagnosis cannot be made with certainty. It would be of considerable service to the clinician, however, if the roentgenologist could identify the group of patients who clinically show clear signs of an acute or chronic inflammatory process. In an attempt to do this, it has been most useful to emphasize the roentgen changes that may be associated with spreading infections arising from individual diverticula. On this basis, the search is made for localized eccentric changes related to the bowel wall. As described below, there are many roentgen appearances which may be produced which differ considerably from the classical saw-tooth segmental deformity. The so-called complications of diverticulitis[10] are then considered to be intrinsic features of the disease and also serve to identify several varieties of clinical pictures that these patients present.

In order to demonstrate the roentgen findings in diverticulosis and diverticulitis, illustrations have been selected from 24 different cases. The examinations have all been done by barium enema and, in most cases, air has also been injected after evacuation. In general, the roentgen findings of diverticulitis are more difficult to demonstrate than, for example, the findings in carcinoma because of the frequent irritability of the bowel and often a pre-existing deformity due to the presence of diverticula. We have frequently found that the most informative roentgenograms are those taken during the course of the barium enema, that is, by the spot technique. Phases of maximum filling, transitory functional changes and local fixation are best visualized in this fashion. Since most of the lesions are of localized character and eccentric in location, small changes may be missed unless optimum spot views are taken. It is also necessary that the spot roentgenograms be of good quality in order that the eccentric intraluminal defects be demonstrable within the barium column. The injection of air after evacuation has often given important information because maximum distensibility is more frequently achieved by air than by barium. In the presence of disease, the bowel usually cannot be completely distended by the air and a useful view of the surface pattern of the bowel can also be obtained. There has been no complication as a result either of the barium enema or of the instillation of air, but it must be noted that barium enema examination has not been done during the most acute phases of the disease.

In attempting to describe the roentgen findings, certain terms have been used in rather arbitrary conventional fashion, which serve to distinguish between functional and anatomic changes. Anatomic changes should produce reproducible predictable appearances whenever satisfactory filling with either barium or air is possible. Functional changes may also be reproducible but the abnormal configuration is usually variable, if not during a single examination, at any rate from one examination to another. The term "spasm" has been used to a considerable degree in roentgen literature. It is applied[5] to a segment of bowel which is rather markedly narrowed as a result of local contraction and remains narrowed over a considerable period of time, frequently throughout the entire barium enema examination. Such a segment may suddenly relax and distend in relatively normal fashion. It is useful to distinguish spasm of this type from "irritability," in which irregularly distributed short segments of the bowel may contract and relax in rapid succession. The most common functional change is a minimal limitation in the ability of the bowel wall to distend completely. This is usually associated with a failure to elongate or "extend" in normal fashion and to assume a normal smoothly curved course. Failure to elongate normally or limitation of extensibility is associated with a transverse parallel arrangement of thick plicae across the bowel lumen, resembling a palisade configuration. These thick folds are not edematous but result

mechanically from failure of the longitudinal muscle of the bowel to relax. In this sense, this palisade arrangement may be referred to as a contracted haustral pattern. Failure to elongate may be more marked on one border of the bowel than the other. This will produce a kind of shirring or pleating effect along the shorter border with radiation of folds towards the shorter border. Under such circumstances, some irregularity of the normally extensible opposite contour is also to be expected. Irritability in the bowel adjacent to a region of active diverticulitis is sometimes manifested by rather deep and broad but smooth thumb-like impressions which suggest incisura-like defects. In a segment of bowel with limited distensibility, the ability to contract normally is also affected. As a result, contraction is usually irregular and evacuation of barium incomplete. Air frequently is trapped in such a segment. Evacuation of the proximal bowel may also be incomplete since the functionally disturbed segment does not participate normally in the mass movements required for complete emptying.

In contrast to spasm which typically causes concentric or uniform narrowing of a length of bowel, eccentric narrowing of a segment of bowel is more likely to be based on local anatomic changes. A well-de-

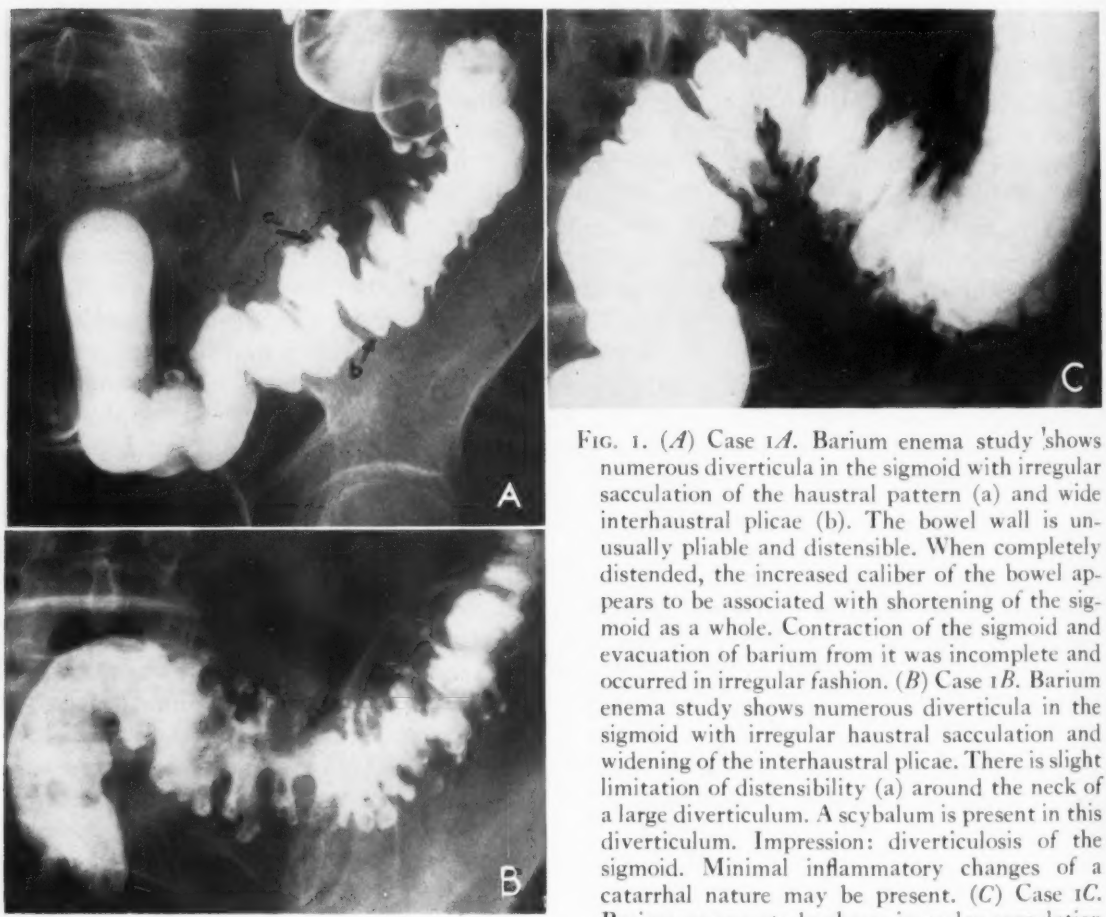

Fig. 1. (*A*) Case 1*A*. Barium enema study shows numerous diverticula in the sigmoid with irregular sacculation of the haustral pattern (a) and wide interhaustral plicae (b). The bowel wall is unusually pliable and distensible. When completely distended, the increased caliber of the bowel appears to be associated with shortening of the sigmoid as a whole. Contraction of the sigmoid and evacuation of barium from it was incomplete and occurred in irregular fashion. (*B*) Case 1*B*. Barium enema study shows numerous diverticula in the sigmoid with irregular haustral sacculation and widening of the interhaustral plicae. There is slight limitation of distensibility (a) around the neck of a large diverticulum. A scybalum is present in this diverticulum. Impression: diverticulosis of the sigmoid. Minimal inflammatory changes of a catarrhal nature may be present. (*C*) Case 1*C*. Barium enema study shows irregular sacculation of the haustral pattern associated with numerous diverticula. This segment of the bowel is unusually distensible and appears relatively shortened. Multiple roentgenograms demonstrated that the bowel wall was uniformly flexible. "Serration" of this type is not evidence of diverticulitis. Impression: diverticulosis.

marcated spherical or ovoid eccentric narrowing is easily recognized and termed a "filling defect" or mass lesion. A poorly demarcated area of induration, which may be manifested only by reproducible flattening of one contour when completely distended, is more difficult to detect. When the induration is more extensive, narrowing of the bowel may be obvious and its organic nature identified by its constancy. Since, in diverticulitis, the induration is inflammatory in nature and does not involve all the layers of the bowel wall, the resultant flattening or narrowing does not have the complete rigidity and exact reproducibility of a malignant neoplastic process. Limited distensibility and extensibility of intramural inflammatory origin may be designated as "restrictive" or "constrictive" to avoid the malignant connotation of the term "rigid."

PERTINENT CLINICAL FEATURES OF ILLUSTRATED CASES

Cases 1*A*, 1*B*, 1*C*. The clinical features in these 3 cases are essentially the same. There was no history of attacks or episodes of severe or localized abdominal pain and no evidence of any significant febrile episode. There were occasional periods when these patients complained of rather diffuse abdominal discomfort and irregular bowel habit. Clinically, therefore, these are instances of diverticulosis rather than diverticulitis (Fig. 1, *A*, *B* and *C*).

Case II. This male of fifty-eight years of age without any previous complaints, nine days prior to admission suddenly developed abdominal pain, distention and fever. On admission, an elongated tender mass was palpable in the left lower quadrant. Temperature was 102.5° and the white blood cell count was 20,000. With conservative therapy including the use of antibiotics, the acute symptoms subsided over a period of about three weeks. Barium enema examination was then done (Fig. 2, *A* and *B*).

Case III. This fifty-four year old obese male without previous complaints was admitted because of the sudden onset of pain in the lower abdomen, fever of 103.5° and a white blood cell count of 15,000. On examination, this patient showed evidence of general peritonitis. Exploratory laparotomy was performed and a perforated sigmoid diverticulum found. An attempt was made to seal off the perforation with omentum and a drain was put down to this region. After three weeks of antibiotic and other conservative therapy, the acute symptoms subsided and barium enema examination (Fig. 3) was performed.

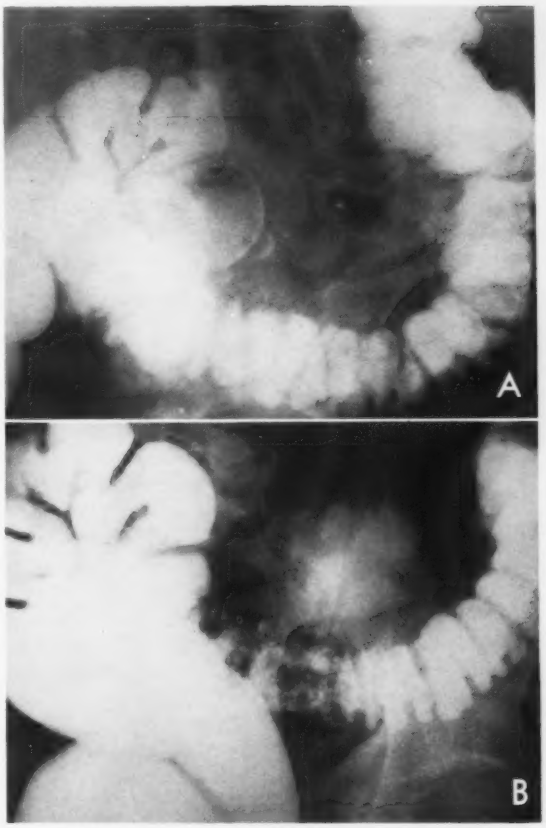

Fig. 2. Case II. (*A*) Spot film of the sigmoid taken during barium enema shows scattered diverticula and a somewhat contracted haustral pattern. There is no remarkable narrowing, deformity or compression of the bowel lumen. (*B*) On films taken after the remainder of the colon was filled, an abscess cavity, partially filled with barium, is seen above the sigmoid. A communicating channel with the bowel lumen was not visualized. Air has collected within the mid-sigmoid, giving it a mottled appearance. This film illustrates a common location for extrinsic abscesses and presumably indicates a relationship to the mesentery of the sigmoid. Impression: perforated sigmoid diverticulum with extrinsic abscess formation; sinus to sigmoid.

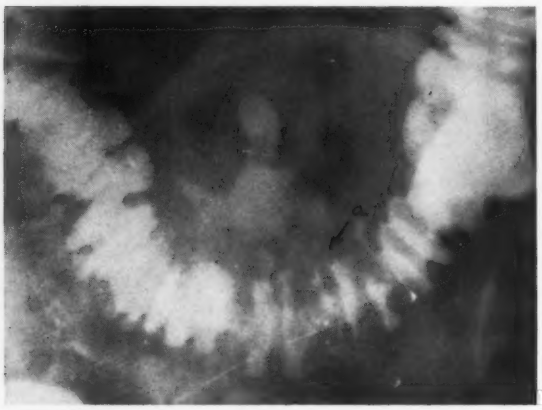

FIG. 3. Case III. Spot film of the sigmoid taken during barium enema study shows a stellate extracolonic collection of barium. Numerous diverticula were present throughout the sigmoid. The haustral pattern of the sigmoid is contracted. Over a short segment (a), the folds appear to be unusually thick, possibly the result of edema in the wall. There is no remarkable deformity, compression or narrowing of the lumen. Impression: perforated sigmoid diverticulum with extrinsic abscess formation; sinus to sigmoid.

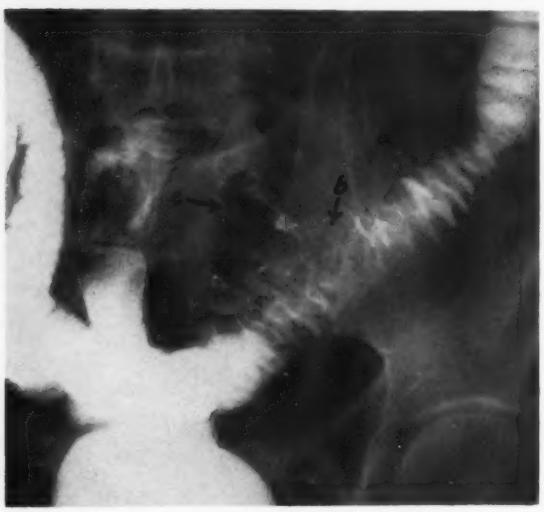

FIG. 4. Case IV. Barium enema examination shows failure of the sigmoid to elongate or distend normally with a coarse mucosal pattern. "Palisading" of plicae (a) in the proximal sigmoid indicates lack of extensibility, *i.e.*, longitudinal spasm. The mucosal pattern (b) within a short segment of the mid-sigmoid appears distorted and hazy (edema). From this region, a diverticulum-like outpocketing extends superiorly. Presumably related to this, there is an ovoid collection of air (c) and a large number of scattered mercury droplets (from a ruptured suction tube balloon) which partially outline an extracolonic abscess cavity. This cavity filled with barium on later films.

FIG. 5. Case V. Spot film of the sigmoid during barium enema study shows a fixed short-loop configuration of the proximal sigmoid with evidence of extrinsic compression along its superior concave margin. The mucosal folds are somewhat thickened but regular, and radiate towards the relatively shorter superior border. Distention of this loop is incomplete. No diverticula are visualized along the compressed margin but several small diverticula appear to be present on the opposite inferior border. There are numerous broad-necked diverticula elsewhere in the colon. The distal sigmoid appears somewhat irritable as indicated by multiple incisura-like projections (a). Impression: perforated sigmoid diverticulum with extrinsic abscess. (Description of specimen in text.)

CASE IV. This male aged fifty-seven, had no previous complaints referable to the gastrointestinal tract. Several days before admission, he suddenly complained of abdominal pain which was followed by persistent vomiting and abdominal distention. At the onset, there were several loose stools, but these were followed by obstipation. He was admitted to another hospital and treated with an intestinal suction tube. On transfer to this hospital, physical examination showed an acutely ill male with a distended, diffusely tender abdomen. His temperature was 102°, the white blood cell count was 18,500 with a shift to the left. Roentgenograms of the abdomen showed evidence of a paralytic ileus. The patient was treated conservatively with intubation and antibiotics over a period of four weeks. Barium enema examination (Fig. 4) was then done. Since discharge, *i.e.*, for the past three years, the patient has complained only of occasional left lower

quadrant discomfort. A repeat barium enema examination, done several months after the original observations, demonstrated the extrasigmoidal abscess cavity to be still present but markedly decreased in size.

Case v. This forty-two year female had an acute episode of abdominal pain five months before admission. Two months after this episode, exploratory laparotomy done elsewhere was said to have shown evidence of sigmoid diverticulitis. A week before admission to this hospital, she complained again of rather severe lower abdominal pain associated with fever and tenderness in the region of the abdominal incision. On admission, her temperature was 103.6° and a tender mass was felt deep to the incision. Within a few days, an abscess ruptured spontaneously through the old wound. With subsidence of fever, barium enema study (Fig. 5) was done. The cutaneous fistula failed to close, and six months later, after a diverting colostomy, a sigmoid resection was performed. At operation, there were numerous adhesions between the sigmoid and adjacent small bowel loops and the anterior abdominal wall. Sigmoid resection was performed. The specimen showed a 2 cm. long stalk of fibrous tissue which contained a narrow fistulous tract which opened into the sigmoid at the site of a diverticulum.

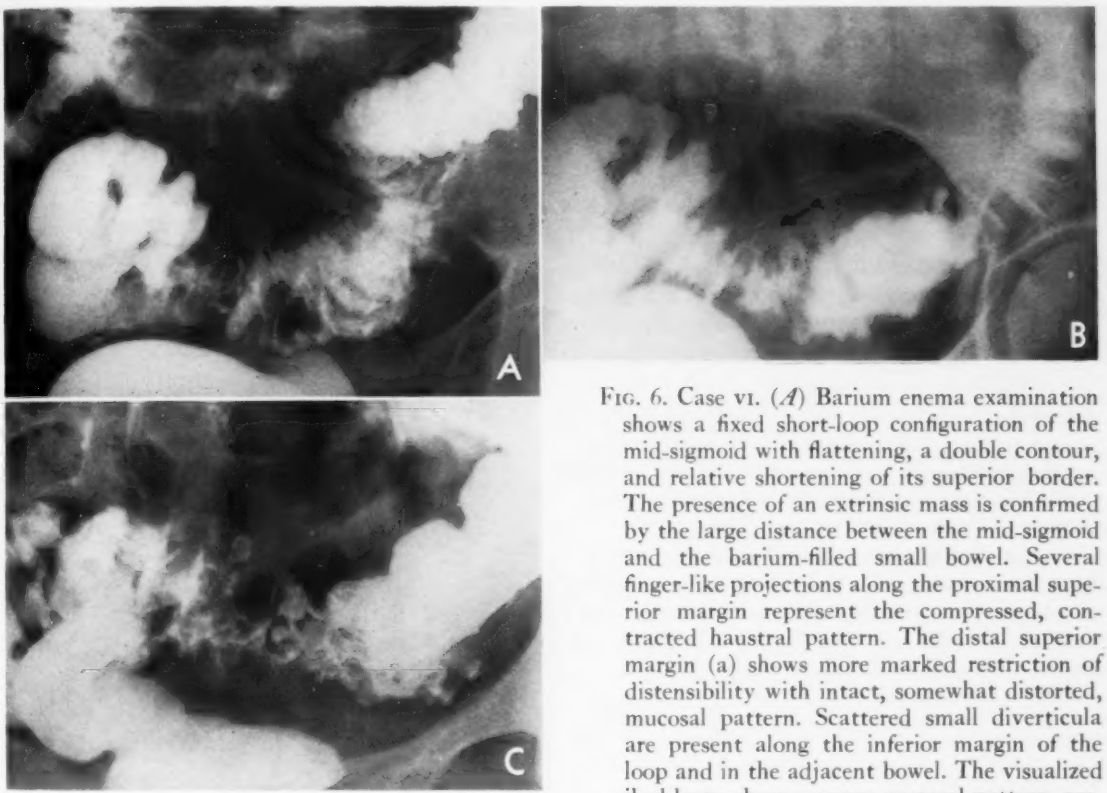

Fig. 6. Case vi. (*A*) Barium enema examination shows a fixed short-loop configuration of the mid-sigmoid with flattening, a double contour, and relative shortening of its superior border. The presence of an extrinsic mass is confirmed by the large distance between the mid-sigmoid and the barium-filled small bowel. Several finger-like projections along the proximal superior margin represent the compressed, contracted haustral pattern. The distal superior margin (a) shows more marked restriction of distensibility with intact, somewhat distorted, mucosal pattern. Scattered small diverticula are present along the inferior margin of the loop and in the adjacent bowel. The visualized ileal loops show a coarse mucosal pattern, presumably the result of edema due to a local peritonitis. Impression: sigmoid diverticulitis with extrinsic abscess. (*B*) Follow-up barium enema examination was done twenty months after the original observations. Spot view of the sigmoid shows no definite evidence of an extrinsic mass. The previously involved segment, however, shows marked limitation of distensibility of its superior wall which has a very irregular somewhat spiked contour (a). This lack of distensibility appears to be due to structural changes in the nature of induration and stiffening of the superior wall since it is present when the bowel is maximally distended with barium. In view of the previous findings, this configuration is indicative of a localized constrictive or restrictive peritonitis with peritoneal adhesions and induration of the subserosal tissues. No diverticula are visualized in the involved segment. Impression: induration of sigmoid due to previous diverticulitis. Question of chronic active infection—chronic diverticulitis. (*C*) Same examination as *B* after evacuation. The involved segment has contracted in an irregular fashion and emptying of the colon proximal to it is incomplete. The mucosal pattern is distorted with a suggestion of radiation towards the superior border, but there is no evidence of destruction of mucosa.

Fig. 7. Case vii. Barium enema examination shows marked lack of distensibility in the mid-sigmoid (a) with evidence of irritability of the bowel both proximally and distally. The mucosal pattern in the contracted segment appears to be intact and has a somewhat ribbed appearance. The margins of this segment appear to be smooth and its lumen is essentially concentric in relation to the adjacent bowel. Above this segment, there is a narrow extracolonic irregular sinus tract (b). There are numerous scattered diverticula throughout the bowel. Impression: recent acute diverticulitis with extrasigmoidal sinus track.

There was some induration of the serosal fatty tissues in the area of the fistulous tract and several other small areas of induration and scarring in the serosa, somewhat removed from the fistulous tract. The sigmoid wall and the mucosa, however, did not appear remarkable.

Case vi. This woman, aged fifty, for four years had complained of periods of abdominal distention with obstipation. These were relieved by passage of gas or a bowel movement. A barium enema study done four years prior to admission was said to have been negative. Two days prior to admission, she began to complain of lower abdominal pain and vomiting. On admission, examination showed tenderness in both lower quadrants. Her temperature was 101° and the white blood cell count was 12,200. A tender mass was felt high in the cul-de-sac on rectal examination. On sigmoidoscopy, the impression was gained that the rectosigmoid was narrowed by extrinsic pressure. Barium enema examination (Fig. 6*A*) confirmed the clinical diagnosis of a perisigmoidal mass due to a perforated diverticulum. On conservative therapy with antibiotics, the acute symptoms and signs disappeared in two to three weeks and the patient was discharged. She continued to complain of periods of abdominal distress which, however, were not sufficiently severe to require hospitalization. Barium enema examination was repeated (Fig. 6, *B* and *C*) two years after the original observations.

Case vii. This sixty-two year old male was examined (Fig. 7) because of moderate low abdominal pain of short duration. There was local tenderness in the left lower quadrant. Temperature and white blood cell count were not recorded. The patient became asymptomatic in about two weeks with conservative therapy.

Case viii. This sixty-nine year old female without previous abdominal complaints four days prior to the barium enema examination complained of left lower quadrant pain. The patient was said to be febrile and to have a leukocytosis (of unknown amount). As preparation for the barium enema study, castor oil was administered and, on the day of the examination (Fig. 8), the patient was almost asymptomatic.

Fig. 8. Case viii. Barium enema study shows a spastic segment in the mid-sigmoid with intact mucosal pattern. The superior margin is flattened and indistinct (a). The folds along the inferior margin of this segment have a somewhat variable size but do not appear to radiate in any particular direction nor to be markedly distorted. No diverticula are seen within the involved segment although the remainder of the bowel shows scattered diverticula. (Dense calcifications over the left side of the pelvis are due to calcified fibroids.) Impression: roentgen findings are consistent with a recent acute diverticulitis.

Case IX. This fifty year old male had had an episode of abdominal pain six years prior to this examination (Fig. 9). The present episode was of several days duration and consisted of severe low abdominal pain with burning on urination. Temperature was 102°. On conservative therapy with antibiotics, the symptoms subsided in about ten days.

Case X. This male, aged seventy-eight, was admitted because of colicky left lower quadrant pain of several days duration. The previous history was not contributory except for the fact that he was a known diabetic of many years' duration. At the onset of the pain, he complained of some diarrhea which lasted for a couple of days, but this was followed by obstipation. On admission, his temperature was 100.8°, the white blood cell count 10,000. In the left lower quadrant, there was deep tenderness but no evidence of rebound tenderness. Barium enema examination (Fig. 10, *A* and *B*) was done on the third day of admission when the patient was afebrile. After a short interval of conservative therapy, the patient became asymptomatic.

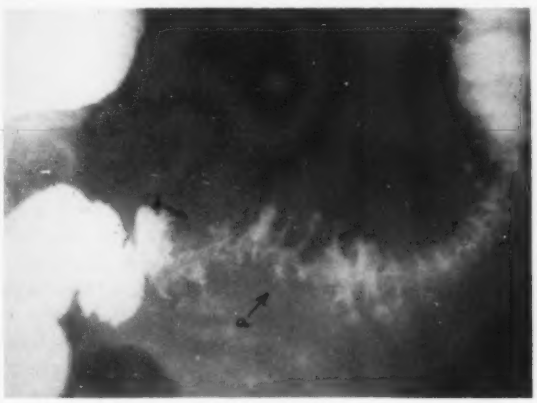

Fig. 9. Case IX. Barium enema examination shows marked irritability of the sigmoid with failure to relax and permit normal filling. On the inferior aspect of the mid-sigmoid, there is in addition a rather broad eccentric defect (a) covered by intact somewhat thickened but undistorted mucosal folds. A short distance distal to this on the superior wall there also appears to be an eccentric defect (b) of smaller size. The mucosal folds over this defect are irregular in configuration. (Multiple faint opacities below the sigmoid are due to opaque material in the buttock.) Impression: roentgen findings suggest that an acute diverticulitis is present. It is likely that there is also an older indurated area of previous diverticulitis.

Case XI. (Fig. 11, *A* and *B*) This sixty year old male was said to have had several episodes of left lower quadrant pain associated with fever and occasional diarrhea over a period of two to three years. His last episode, however, had occurred several months before this admission. Patient was admitted to the hospital because of rectal bleeding. Barium enema study about one and one-half years prior to this examination was said to have shown evidence of diverticulitis.

Case XII. (Fig. 12*A*) This fifty-five year old female over a period of several years had had several episodes of left lower quadrant pain associated with fever. The present admission, however, was for a hemorrhagic cystitis demonstrated on cystoscopy. This was assumed to be related to the presence of a cystocele.

Case XIII. (Fig. 12*B*) This female, aged fifty-eight, complained occasionally of some mild lower abdominal discomfort.

Case XIV. (Fig. 12*C*) This forty-six year old male complained of left lower quadrant pain off and on over a period of about two years. For about two or three days prior to admission, there had been moderate diarrhea. There was no history of fever associated with these episodes of pain. Examination showed some thickening in the left lower quadrant but no evidence of a mass and no remarkable local tenderness.

Case XV. This woman, aged sixty, was admitted with a history of occasional abdominal pain and constipation, occurring episodically over a period of several years. Her chief complaint, on admission, was pneumaturia which began two months prior to admission. Examination was essentially negative except for a sensation of thickening in the left lower quadrant. Barium enema examination (Fig. 13) confirmed the presence of a fistula from the sigmoid to the bladder. A diverting colostomy was done, followed by exploration and resection of the sigmoid. The fistulous tract was found and transected. A number of diverticula were present in the specimen, none of which were larger than a peanut. These extended into the subserous fatty tissue. Many of them contained inspissated greenish casts consisting of mucopus. There was only slight peridiverticular scarring.

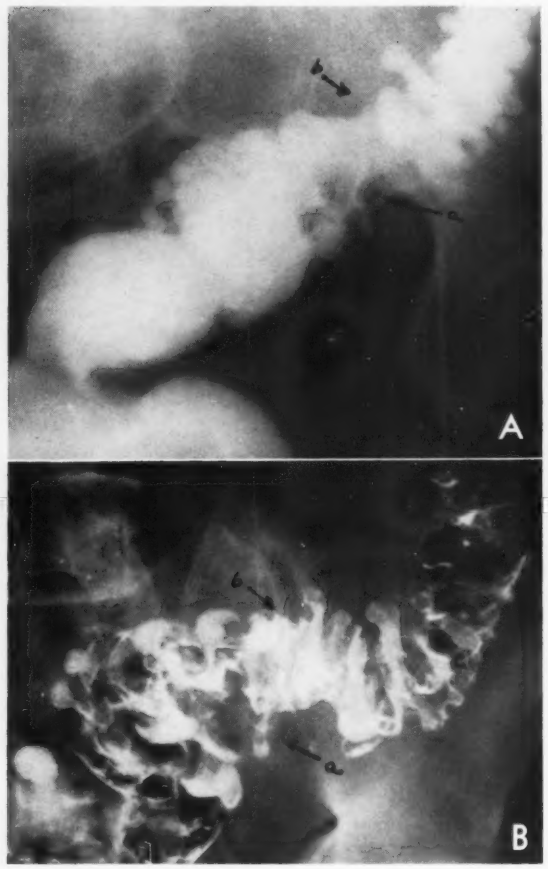

Fig. 10. Case x. (*A*) A spot film of the sigmoid taken during barium enema study shows an irregular defect (a) along the inferior wall of the mid-sigmoid with straightening (b) of the opposite contour over a short distance. Numerous diverticula are present in the adjacent bowel. (*B*) The same examination—double contrast. The irregular defect (a) is again demonstrated. It appears to be sharply delimited from the lumen. The mucosal folds over the defect are intact but somewhat thickened. A short flat segment of the opposite wall shows several small spikes (b). Impression: probable acute diverticulitis with an intramural inflammatory mass. The lack of irritability in the adjacent bowel suggests that the acute process is subsiding.

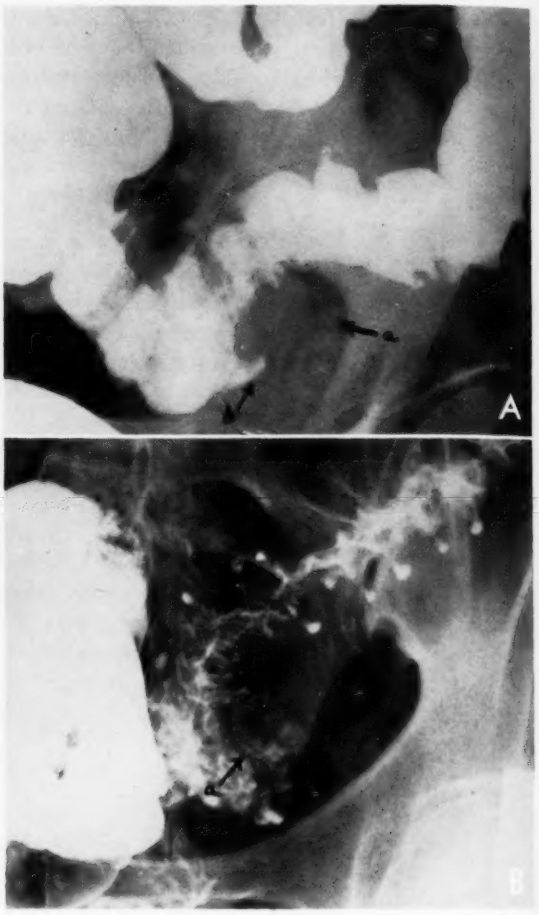

Fig. 11. Case xi. (*A*) Barium enema study shows a sharply demarcated, rather flat intramural defect (a). Shallow, somewhat irregular folds are seen over its mid-portion but no folds are seen on either lateral aspect. The lumen of the bowel appears to envelop the defect distally, producing a re-entrant angle (b). The corresponding angle proximally is markedly obtuse. There is no evidence of spasm or irritability. Numerous scattered diverticula are present in the adjacent bowel. (*B*) Same examination after evacuation. The defect is constant. The mucosal folds over the defect are well demonstrated and are intact but appear to radiate towards the defect. In addition, there is an irregular smudge of barium (a) apparently within the distal portion of the defect. Impression: chronic intramural abscess or granuloma due to diverticulitis. The lack of irritability and the sharp delimitation of the lesion suggests that it is not of recent origin.

Case xvi. This male, aged fifty-two, had for many years complained of episodes of constipation and abdominal cramps. During the previous two years, there had been three fairly severe such episodes. At these times, associated with the pain, there was some fever and general malaise. For about a year prior to admisssion, there had been occasional diarrhea, alternating with constipation. Three years before admission, a diagnosis of diverticulosis had been made on barium enema examination. Four weeks prior to admission, pus, blood and fecal

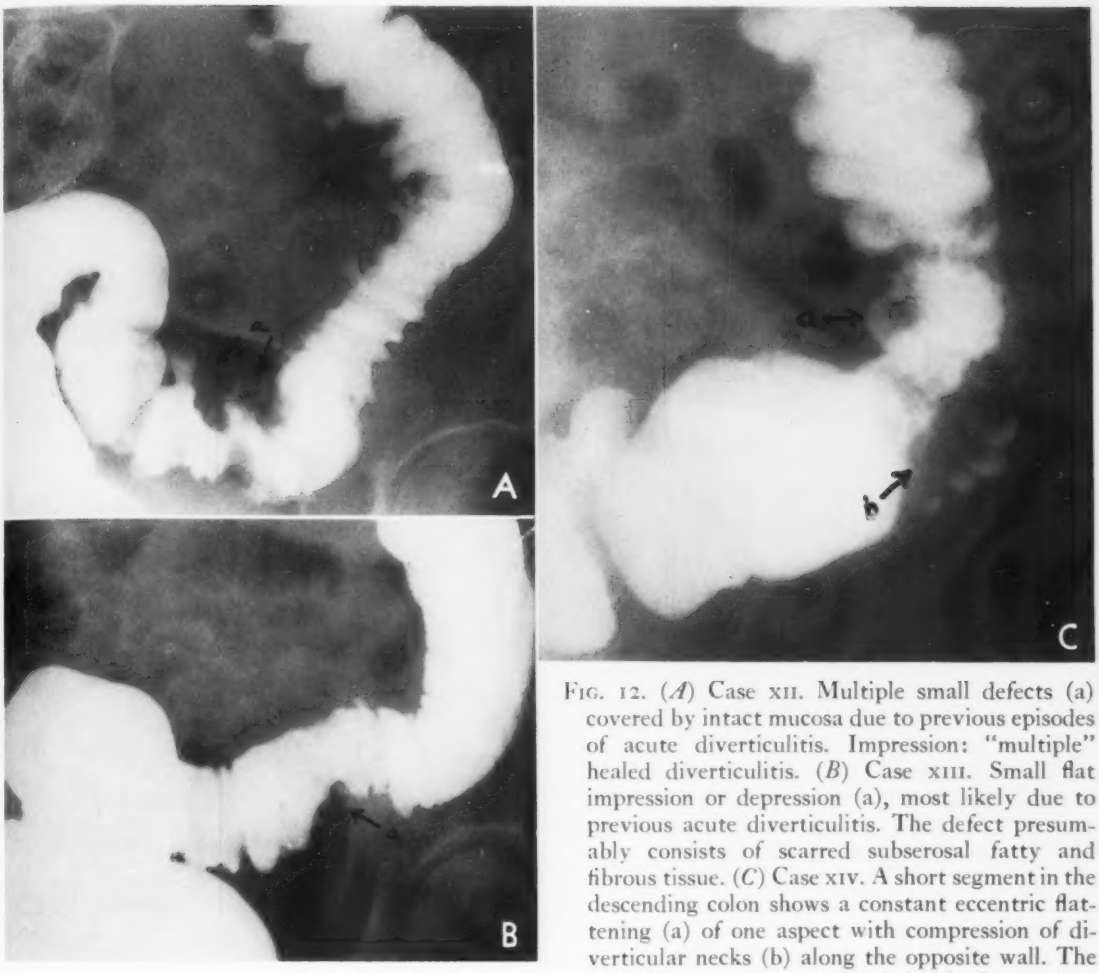

FIG. 12. (*A*) Case XII. Multiple small defects (a) covered by intact mucosa due to previous episodes of acute diverticulitis. Impression: "multiple" healed diverticulitis. (*B*) Case XIII. Small flat impression or depression (a), most likely due to previous acute diverticulitis. The defect presumably consists of scarred subserosal fatty and fibrous tissue. (*C*) Case XIV. A short segment in the descending colon shows a constant eccentric flattening (a) of one aspect with compression of diverticular necks (b) along the opposite wall. The sigmoid appeared somewhat irritable. Impression: subacute (?) diverticulitis.

material appeared in the urine. The patient was afebrile, the white blood cell count was 5,200. Hemoglobin was 15 gm. Cystoscopy showed an ulcerated area on the posterior superior wall of the fundus of the bladder. Barium enema examination (Fig. 14*A*) confirmed the clinical impression of diverticulitis although a fistulous tract was not demonstrated. A diverting transverse colostomy was performed, followed in about four months by sigmoid resection. A small abscess cavity was found between the sigmoid and the bladder which communicated by short fistulous tracts with these viscera. The specimen (Fig. 14*B*) showed multiple diverticula, one of which connected with the fistulous tract which extended around subserosally to the anti-mesenteric border of the bowel. This track was filled with creamy purulent material. Over a segment 2½ to 3 inches long, there was marked thickening of the subserosa and marked hypertrophy of the muscular layer.

CASE XVII. This seventy-three year old man complained occasionally of left lower quadrant pain for a period of about fifteen years and of gradually increasing constipation. Barium enema examination (Fig. 15) was done to rule out carcinoma.

CASE XVIII. This sixty-two year old female complained of episodes of abdominal pain and increasing constipation for about a year and a half. For the past five months, the pain had been more severe on the left side of the abdomen. Over this period, there had been about a 10 pound weight loss. On admission, the find-

Fig. 13. Case xv. Spot view of sigmoid during barium enema examination shows restricted distensibility and fixation of the distal sigmoid with failure to elongate normally. There are two areas (a, b) of more localized eccentric defects. The contours of the maximally distended bowel in this segment are irregularly distorted, that is, the residual haustral pattern is bizarre in configuration. The mucosal folds appear to radiate towards the center of the defect located on the inferior margin below which there is a collection of extracolonic barium (c). This was in a small abscess cavity which was demonstrated on later roentgenograms to communicate with the bladder. The mid-sigmoid shows a contracted haustral pattern (d) with symmetric undistorted margins. The proximal sigmoid (e) shows changes of diverticulosis. Impression: chronic diverticulitis with vesical fistula. (Description of specimen in text.)

ings were essentially negative except for those of the barium enema examination (Fig. 16). A sigmoid resection was done. The sigmoid was markedly indurated and fibrotic and densely adherent to the lateral and retroperitoneal tissues. The external surface of the sigmoid was covered with indurated hyperemic fatty tissue with focal areas of hemorrhage and stellate scarring and contraction. The lumen was constricted by marked thickening of the subserosa and marked hypertrophy of the muscularis. The mucous membrane was smooth with small areas of hyperemia and edema. Several diverticula extending into the appendices epiploicae were present.

Case xix. (Fig. 17, *A* and *B*) This seventy-two year old female over a period of many years had had multiple attacks of left lower quadrant pain and fever lasting one to two days. During one of these episodes five years prior to the present observations, she had been hospitalized and a diagnosis of diverticulitis had been made.

Case xx. (Fig. 18) This was a male, aged sixty. A reliable history is not available, but for at least six weeks there had been progressive constipation and for about four weeks progressively severe crampy abdominal pain. Sigmoid resection was performed. Specimen showed thickening and induration of the wall over a distance of about 2½ inches with a submucosal sinus tract which contained purulent material. This communicated with the lumen of the bowel through multiple openings. Areas of ulceration surrounded these openings and there were minute inflammatory polypoid changes at the edges of the ulcerations. Short fistulae also extended into the subserosal fat

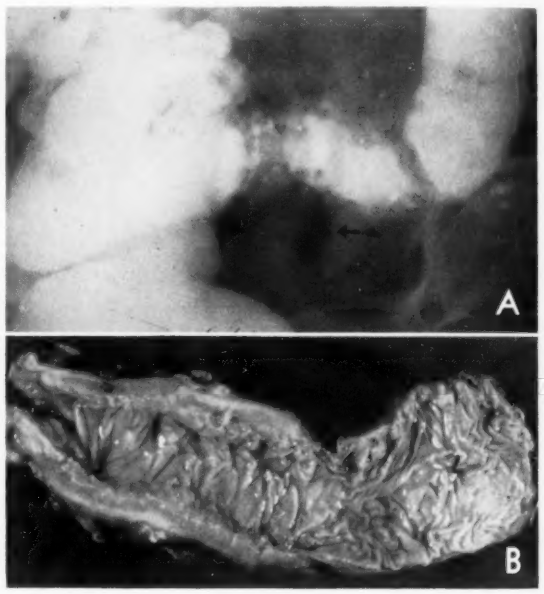

Fig. 14. Case xvi. (*A*) Barium enema examination shows a short fixed segment of the mid-sigmoid with restricted distensibility and restricted extensibility. The margins of this segment are somewhat irregular. Below this region, there is an ovoid collection of air (a) outside the colon and presumably in the bladder. No barium entered the vesical fistula during this examination. Impression: chronic indurative diverticulitis with vesical fistula. (*B*) Photograph of resected specimen. The wall of the sigmoid is markedly and rather uniformly thickened over a distance of about 2½ inches. This thickening is predominantly due to subserosal fibrotic chronic inflammatory tissue and marked hypertrophy of the muscular layer. The submucosa is moderately thickened. The mucosa is intact.

but the peritoneum over the sigmoid appeared to be intact. Several diverticula could be probed at various places in the specimen.

Case xxi. (Fig. 19) This seventy-six year old male had had a barium enema examination six and one-half years before because of rectal bleeding. The examination was reported to have shown diverticulosis with spasm and some distortion of the mucosal pattern. Shortly after this, he began to complain of occasional abdominal cramps which were controlled by antispasmodics. In the two weeks before admission to the hospital, however, the abdominal crampy pain had become more severe and associated with some vomiting and slight weight loss. The patient was afebrile. Examination of the abdomen showed no evidence of any mass and only slight tenderness on the left side.

Case xxii. This fifty-eight year old male gave a history of episodes of left lower quadrant pain associated with fever and diarrhea over a period of about one and one-half years. At times, a mass could be felt in the left lower quadrant. During this interval several barium enema examinations were done (Fig. 20, *A*, *B* and *C*). Because of persistent bloody diarrhea and pain, a resection of the sigmoid was performed after a preliminary colostomy. The specimen showed a large amount of indurated pericolonic fat. The serosa was congested and shaggy with numerous appendices epiploicae firmly adherent to the surface of the bowel. The mucosa showed openings of numerous diverticula throughout. About many of these openings, the mucosa was reddened with small 3 mm. polypoid changes. Probing of several of these diverticula led into a large submucosal sinus tract. In the vicinity of the openings, there was bridging of the mucosa and other less affected diverticula showed some undermining of the mucosa. The mucosal rugae were in general very prominent as a result of the bridging and the small polypoid changes. The muscularis showed segmental areas of marked hypertrophy. The lumen of the bowel was somewhat narrowed.

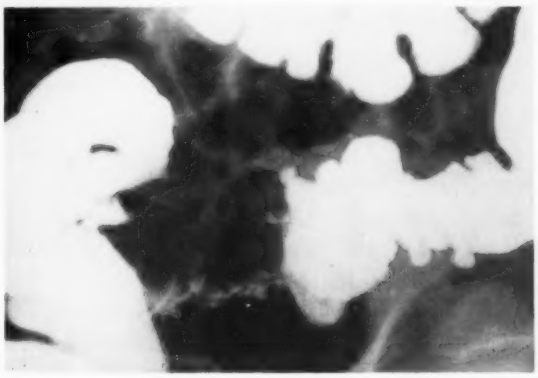

Fig. 15. Case xvii. Barium enema examination shows marked narrowing of the mid-sigmoid with intact but distorted mucosal pattern. This segment was unchanged in appearance and location during the entire examination. No diverticula were filled in relation to the narrowed segment, but there were numerous diverticula elsewhere in the colon. There was no evidence of overhanging edges at either margin. Impression: chronic indurative diverticulitis.

Fig. 16. Case xviii. Barium enema study shows marked narrowing of the proximal sigmoid which was constant throughout the entire examination. The mucosal pattern throughout this segment appears to be intact but consists of numerous interlacing short irregular folds. The transition to adjacent distensible bowel is rather abrupt but conical in shape. Impression: chronic indurative diverticulitis. (Description of specimen in text.)

Roentgen and Pathologic Changes

The etiology of diverticula is not known. It is assumed, however, that they are produced by the effect of intraluminal pressure acting on weakened areas of the bowel wall. This effect in many cases

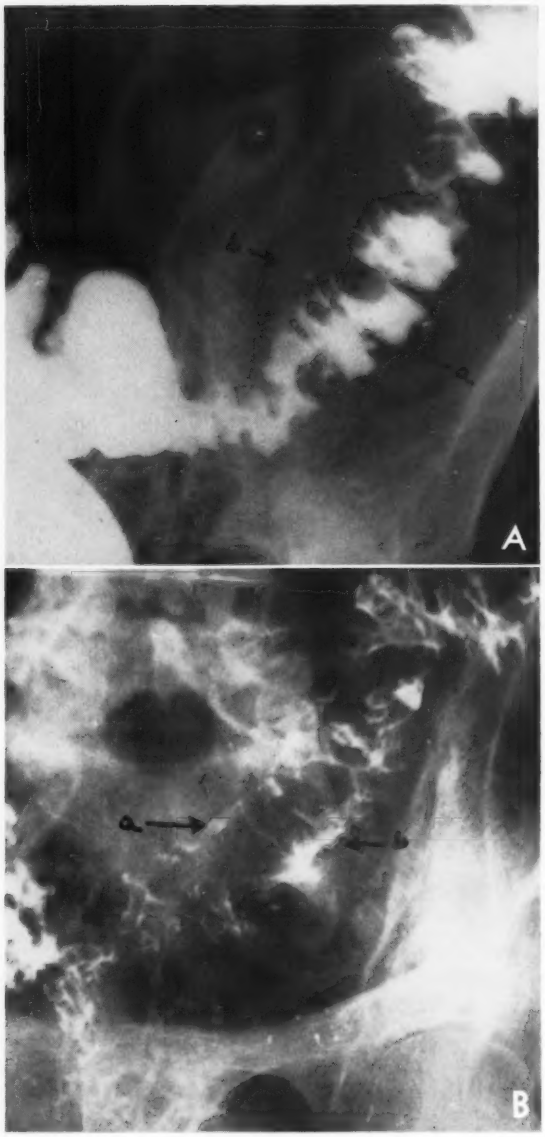

Fig. 17. Case xix. (*A*) Barium enema examination shows thickening of the superior wall of the mid- and proximal sigmoid. This is indicated by the eccentric position of the residual lumen. The inferior border of this segment is normally located with a rather regular pliable contour (a). The superior border shows an irregular dentate contour (b) with fingertip-like projections. The mucosal folds along this border appear to be intact but thickened. Single diverticulum is noted in involved segment; scattered diverticula elsewhere. (*B*) Same examination, after evacuation. A long intramural sinus tract (a) filled with smudgy barium is present within the thickened superior wall. Several thin streaks of barium extend into the lumen (b) from this tract. The distance between the residual lumen and the sinus tract represents thickened, chronically inflamed submucosa and mucosa. Impression: chronic diverticulitis with intramural sinus.

Fig. 18. Case xx. Barium enema study shows a double channel in the mid-sigmoid. The lower channel (a) is the true lumen of the bowel, the upper (b) is a submucosal sinus tract or false passage. Streaks of amorphous barium connect the sinus tract with the lumen. The thick mucosa and submucosa appear to sag toward the lumen of the bowel, producing an irregular dentate margin. No diverticula are visible in the involved segment. Scattered diverticula were noted elsewhere in the bowel. There was no remarkable irritability either in the involved area or in the adjacent bowel. The diseased segment was fixed in position and retained air and amorphous barium after evacuation. An adjacent air-containing loop of small bowel (c) parallels the superior margin of the fistulous tract but is separted from it by a considerable distance. Impression: chronic diverticulitis with intramural sinus tract. (Description of specimen in text.)

appears to be slowly progressive so that diverticula increase in size very slowly over a long period of time. As the diverticulum enlarges, the muscular wall over it becomes thinned and eventually disappears so that the submucosa and subserosa are essentially fused. The diverticulum eventually projects through the serosa, is usually covered by considerable fat and frequently appears to be associated with an appendix epiploica. As a diverticulum extends laterally, there is frequently a sacculation of the involved haustrum (Fig. 1*A*) which frequently appears to diminish gradually in size and end as the diverticulum. This weakening of the haustra permits unusual distensibility of the

Fig. 19. Case xxi. Barium enema study shows a localized intramural defect covered by intact mucosa in the distal descending colon. A long, intramural sinus tract extends from this defect proximally to beyond the splenic flexure. Throughout its course, there are multiple communications through the thickened submucosa with the lumen of the bowel. Impression: chronic diverticulitis with long intramural sinus tract.

bowel (Fig. 1, *B* and *C*) at the expense of longitudinal stretching. As thinning of the wall occurs at the site of the sacculated haustra, there is a corresponding bunching of damaged muscular fibers in between "as when an elastic band is cut or weakened in one place."[8] This produces thick interhaustral plicae (Fig. 1*A*). The roentgen appearance of diverticulosis therefore is characterized not only by the presence of multiple diverticula but, in addition, by a haustral asymmetry in an otherwise flexible bowel. The flexibility of the bowel wall in such instances has been demonstrated by serial filming.[8] With retention of fecal material in a diverticulum and scybala formation, there may be "catarrhal" and microscopic peridiverticular inflammatory changes. These may manifest themselves roentgenologically by some irregularity of the plicae between the haustra or by some flattening around the necks of individual diverticula (Fig. 1*B*). These roentgen findings are, however, not sufficient to warrant the diagnosis of a clinically significant acute or chronic inflammatory process. Spreading inflammatory changes in the nature of a cellulitis with or without abscess formation result from obstruction of the neck of a diverticulum. Because of this obstruction, the specific diverticulum which is the cause of the infection is not visualized on barium enema examination. Since many of these diverticula extend well beyond the border of the bowel, the progress of the inflammatory process may resemble that of an acute appendicitis. Perforation into the general peritoneal cavity is unusual because of the prompt formation of adhesions, but localized abscess formation extrinsic to the bowel is common (Fig. 2, 3, 4, 5 and 6). The purulent material within the center of such an abscess must eventually be evacuated surgically or spontaneously back into the bowel or into an adjacent viscus or through the abdominal wall. With satisfactory drainage, such cases may require no further therapy. There is, however, usually residual fixation of the bowel as the result of the extensive peritoneal adhesions. Moreover, if drainage is incomplete, a chronic abscess may persist with multiple acute exacerbations. As a result of a pericolonic mass, the only roentgen evidence may be that of an extrinsic pressure defect or compression of one border of the bowel associated with functional changes in the adjacent segment of the bowel and some mucosal edema. Local tenderness may be recognizable during fluoroscopic observations. In some instances of extrinsic abscess formation, there is also sufficient subserosal inflam-

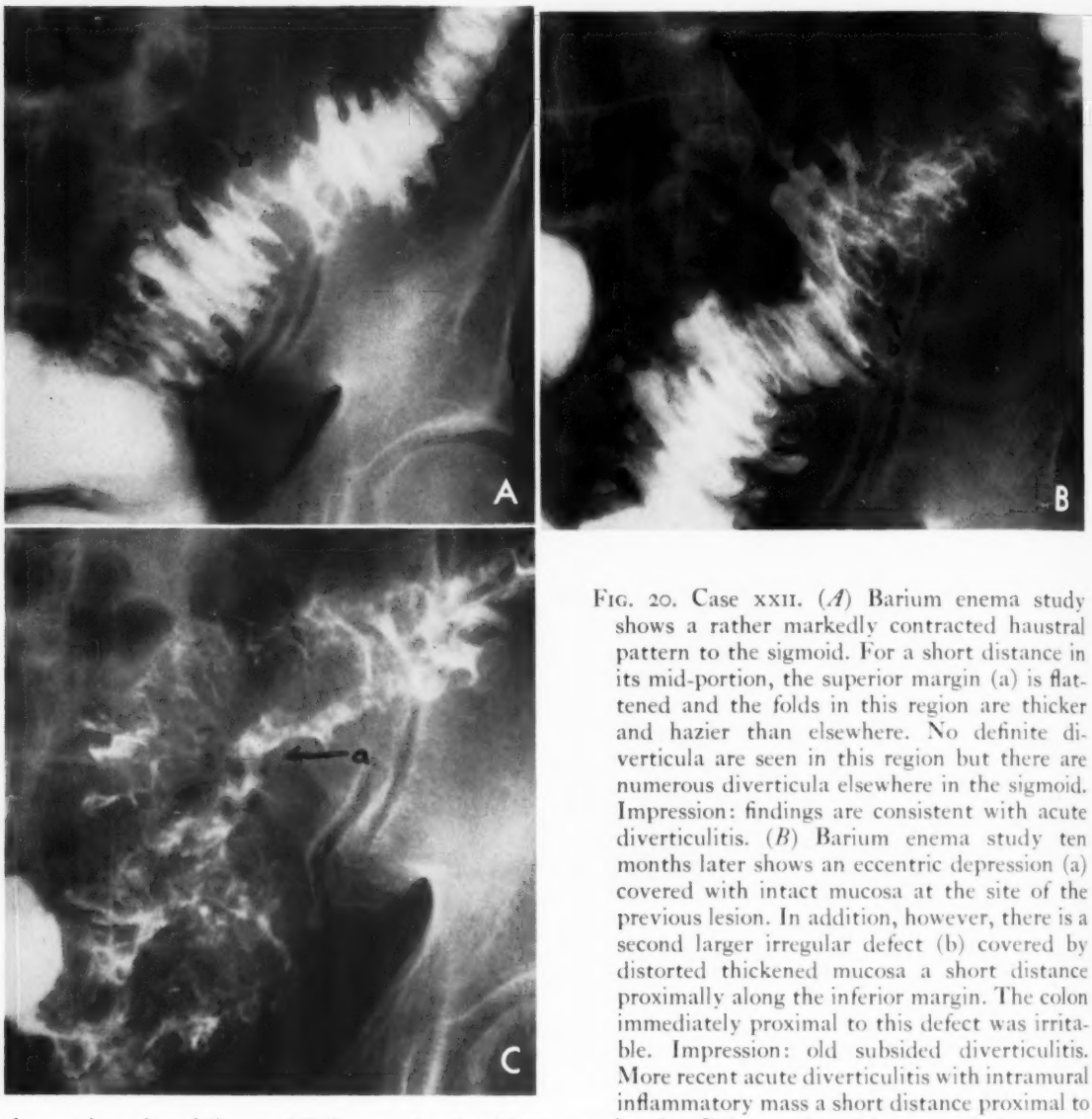

Fig. 20. Case xxii. (*A*) Barium enema study shows a rather markedly contracted haustral pattern to the sigmoid. For a short distance in its mid-portion, the superior margin (a) is flattened and the folds in this region are thicker and hazier than elsewhere. No definite diverticula are seen in this region but there are numerous diverticula elsewhere in the sigmoid. Impression: findings are consistent with acute diverticulitis. (*B*) Barium enema study ten months later shows an eccentric depression (a) covered with intact mucosa at the site of the previous lesion. In addition, however, there is a second larger irregular defect (b) covered by distorted thickened mucosa a short distance proximally along the inferior margin. The colon immediately proximal to this defect was irritable. Impression: old subsided diverticulitis. More recent acute diverticulitis with intramural inflammatory mass a short distance proximal to the previous site of disease. (*C*) Re-examination fifteen months after *B* shows a broad intramural sinus tract (a) at the site of the previous inflammatory mass. Impression: chronic diverticulitis with intramural sinus tract formation. (Description of specimen in text.)

matory exudate to result in permanent deformity (Fig. 6, *A*, *B* and *C*).

If extraserosal perforation does not occur as a result of obstruction and infection of a diverticulum, the acute inflammatory process may be confined to the peridiverticular subserosal tissues. There may be very little to see in such instances roentgenologically since the subserosa is at a considerable distance from the bowel lumen. The only findings may consist of slight flattening of one wall, local spasm, irritability of the adjacent bowel and evidence of some edema of the mucosa (Fig. 7 and 8). When the inflammatory changes are more extensive and approach closer to the lumen of the bowel, an irregular eccentric defect may be demonstrable on barium enema examination (Fig. 9). Functional changes, however, may interfere so much with filling of the bowel that anatomic changes are difficult to demonstrate. Filling

defects of intramural type may be clearly recognizable (Fig. 10). With conservative therapy including antibiotic treatment, the acute inflammatory process may subside. Inflammatory tissue is then gradually replaced by a scarred fatty and fibrotic area (Fig. 11). As a result, some residual deformity is frequently demonstrable on later examinations[11] (Fig. 12, *A*, *B* and *C*). In fact, the late defect is usually more easily demonstrated than changes during the acute phase. A large intramural defect—a "cushion" defect[6]—may persist for many years relatively unchanged. It is likely, however, that diverticula in a segment of bowel which previously was the seat of acute inflammation are more susceptible to infection because of the residual deformity and functional changes resulting in stasis. The term "multiple diverticulitis"[3] is useful to describe this variety of recurring acute diverticulitis.

In another group of cases, however, with purulent infection of a diverticulum and cellulitis of surrounding tissues, although the acute phase may be controlled or be of minimal severtity, the purulent material, retained under pressure, causes a progressive reactive subacute inflammatory process in the wall of the bowel (Fig. 13, 14, 15 and 16). The term chronic indurated or proliferative diverticulitis has been applied to this variety of chronic diverticulitis. In the course of this slow progression, adjacent diverticula may become secondarily involved and obstructed. As a result, there may be exacerbations or flare-ups of acute infection during the course of the chronic progressive inflammatory process and eventually all of the diverticula over a considerable segment of the bowel may be sealed off. If one of these abscessed diverticula happens to be located so that it becomes adherent to an adjacent viscus, usually the bladder, fistula formation is likely. The proliferative process associated with this type of chronic inflammation may become so marked as to produce signs of severe intestinal obstruction. It has been our experience, however, that when complete intestinal obstruction occurs abruptly in an individual with diverticulitis, there is usually a flare-up of acute infection (or a coincidental carcinoma). A rather special variety of chronic diverticulitis occurs when the entrapped purulent material ruptures into the submucosa and produces a fistula within the bowel wall (Fig. 17, 18, 19 and 20). This serves to spread the chronic inflammatory process over a considerable distance and eventually multiple communications with the bowel lumen occur. When this happens, there may be multiple areas of mucosal ulceration with intervening mucosal bridges representing the undermined residual mucous membrane between the ulcerated fistulous openings. Unless this happens, however, the mucosa in diverticulitis is intact. With thickening and contraction of the bowel wall, the mucosal pattern becomes distorted and exaggerated in the sense that it consists of a large number of small interlacing folds—an unusually rugose pattern.[9]

Discussion

As indicated by the large number of illustrations, the roentgen manifestations of diverticulitis are protean and distinct from the haustral deformities of diverticulosis. These changes are the result of purulent infection of a single diverticulum due to obstruction at its neck and interference with its drainage. For this reason, a characteristic feature of diverticulitis is the *failure* to fill with barium the specific diverticulum which is the origin of the inflammatory process. The clinical picture associated with a perforated diverticulum is that of an acute severe inflammatory episode with signs of peritonitis and paralytic ileus. However, in most cases of acute infection of a diverticulum, the peridiverticular inflammatory process is confined to a small area in the serosa and is of minimal severity and short duration. This appears to be true even in cases with extensive mural inflammatory changes, causing irregular defects in the barium column. In a patient predisposed to

diverticular infection, multiple episodes due to serial involvement of different diverticula are common. These minor acute episodes may go on to complete resolution or may leave residual defects or deformities of little significance. The danger of an acute infection, however, is the possibility that a purulent focus may become permanently sealed off from the bowel lumen. This may then lead to a diffuse chronic reactive proliferative type of inflammatory change with fibrosis and marked hypertrophy of the muscular layer of the bowel wall—chronic indurative or proliferative diverticulitis.[9] Since a collection of pus acts as if it were under pressure, internal fistulization is likely to occur. If the purulent material burrows within the wall of the bowel, a long segment of colon becomes chronically inflamed secondarily. A working classification of diverticulitis, on the above pathogenesis, might then be: (1) Acute diverticulitis, with or without perforation. (2) Recurrent or multiple acute diverticulitis. (3) Healed or subsided diverticulitis, single or multiple. (4) Chronic diverticulitis with or without demonstrable fistula and sinus formation. The identification of these varieties of diverticulitis roentgenologically with certainty may be quite difficult and requires clinical confirmation. The diagnosis may have to be made by inference and exclusion of other conditions. It is particularly difficult roentgenologicaly to identify (1) acute episodes in the presence of marked induration due to a chronic diverticulitis; (2) an underlying or coincident chronic process in the presence of a new acute episode associated with marked spasm; and (3) small residual deformities due to previous acute episodes in the presence of a deformed shortened bowel due to severe diverticulosis.

Differential diagnosis between diverticulitis and carcinoma has been discussed in detail by several authors.[4,6] The most useful feature is the demonstration that deformities or defects due to diverticulitis are covered by intact mucosa. This may not be true if multiple sinus tracts are present but such tracts are unusual in carcinoma. Differentiation from benign intramural tumors, metastatic implants, neoplastic infiltration from an adjacent viscus, and radiation changes must also be made. The history and serial studies are of great usefulness in determining the correct diagnosis in such cases.

SUMMARY

1. The roentgen findings in cases of diverticulosis and diverticulitis, as determined by their clinical course, have been reviewed.

2. Correlation of clinical and roentgen findings is most successful if emphasis is placed on eccentric or localized mural deformities or defects, extrinsic masses and demonstration of fistulae. These changes should be considered intrinsic features of diverticulitis rather than complications.

3. Chronic diverticulitis should be differentiated from multiple episodes of acute diverticulitis due to serial involvement of separate discrete diverticula. Chronic diverticulitis is the result of retained pus which leads to a chronic reactive proliferative inflammation with eventual intrinsic and extrinsic fistula formation.

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THE AMERICAN JOURNAL OF ROENTGENOLOGY, RADIUM THERAPY AND NUCLEAR MEDICINE

Editor: Lawrence Reynolds, M.D.

Associate Editors: Harry Hauser, M.D., Traian Leucutia, M.D., Russell H. Morgan, M.D., Edward B. D. Neuhauser, M.D., Wendell G. Scott, M.D.

Consulting Editorial Board: See front cover.

Published by: Charles C Thomas, Publisher, 301–327 East Lawrence Avenue, Springfield, Illinois.

Issued monthly. Annual subscription: United States, Mexico, Cuba, Central and South America, $15.00; Canada, $16.00; other countries, $17.00. Current single numbers, $1.50. Advertising rates submitted on application. Editorial office, 110 Professional Building, Detroit 1, Michigan. Office of publication, 301–327 East Lawrence Avenue, Springfield, Illinois. Information of interest to authors and readers will be found on page vi.

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EDITORIAL

THE GASTROINTESTINAL RADIOLOGIST

THE radiologist who essays examination of the gastrointestinal tract of patients referred to him for his expert opinion assumes a great responsibility, for he is entrusted with the task of supplying objective evidence of disease or well-being of the greater portion of the alimentary tube. To insure the best possible diagnostic effort in this direction, the finest physical and mental facilities should be at hand, and to provide these facilities is the duty of the modern gastrointestinal radiologist. His responsibility in this regard can be divided into three phases: equipment, techniques, and skill.

Equipment. The present day gastrointestinal roentgen equipment has resulted from years of design, use, and revision and has reached a high degree of perfection. Relatively brilliant fluoroscopic screens, fine grids, convenient and versatile spot-film devices allow effortless roentgenoscopic study of the gastrointestinal tract. Fine focus tubes, fast diaphragms, and instantaneous exposures permit uniformly good complementary roentgenograms to complete the examination. But is this enough? Cannot further refinements in gastrointestinal diagnosis be achieved by the use of, for instance, cineroentgenography and image amplification? Undoubtedly there is great merit in any method, such as cineroentgenography, which can display a thousand plastic images of the stomach, and the more satisfactory optical conditions of image amplification fluoroscopy enhance the detail of observation. Both these techniques are in limited clinical use. Whether they represent the final answer to the physical problems of gastrointestinal radiology remains to be seen, but the up-to-date gastrointestinal radiologist should be willing to give up his accustomed, less complex equipment and explore the possibilities of these more time consuming methods.

Of all the areas in the roentgen diagnostic arena, the gastrointestinal room is potentially the most hazardous to the radiologist, to his assistants, and to the patient. Considerable attention has been directed to protection of the radiologist by standardizing fluoroscopic equipment design and by the use of various articles of protective clothing such as the lead glass fabric suits proposed by Archer.[1] Physical survey of the gastrointestinal fluoroscopic room and monitoring with personnel film badges has become an accepted minimal program of protection for the radiologist and his staff. The patient, the object of the oft-times prolonged fluoroscopic and extensive roentgenographic study, has been relatively neglected from the radiation exposure standpoint until recently.

Particular attention has been paid to the possible genetic damage produced by irradiation of the female genital organs since these organs are within the field of interest in roentgen studies of the small and large intestine. Actual dose measurements made clinically during barium enema examination in a group of patients revealed that the female mid-pelvis received a radiation dose between 0.3 and 0.8 r. The dose to the same area during fluoroscopic and roentgenographic study of the upper gastrointestinal tract was considerably lower, 0.1 to 0.3 r. These dosage values[2] should not be transposed or applied to *every* fluoroscopic or roentgenographic installation but must be determined individually. That such determinations might well become an actual part of diagnostic roentgen routine is not impossible, and in the not too distant future precise records of patient radiation dosage may become part of the

radiologist's records, as suggested by Poppel, *et al.*[3] Thereby, the gastrointestinal radiologist will be directly responsible and painfully aware of the contribution of the gastrointestinal examination to the radiation record of his patients.

Techniques. An astounding variety of techniques of examination of the gastrointestinal tract can now be enumerated by the radiologist. Many of these techniques are used every day, others reserved for special problems in diagnosis which arise only occasionally. However frequent or infrequent their use, they should all be readily available.

The gastrointestinal worker has been somewhat hampered in the past by a slavish dependence on barium sulfate as the major contrast material for his use. As a medium, barium is far from ideal, and most innovations of technique have been aimed at circumventing its special disadvantage—uncontrollable density. Especially in respect to demonstration of the mucosal pattern of the intestine, barium-water suspension distends and obscures. To distend without obscuring has been a disturbing problem attacked by radiologists in various ingenious ways. The use of air contrast and barium-air contrast were the earliest attempts at solution of this puzzle, as interestingly related by Stevenson.[4] Employment of a barium-water suspension which coats the mucosa while transparent mineral oil distends the stomach is an approach suggested by Gianturco.[5] In the colon mucosal polyps may be better demonstrated by the use of dilute barium-water suspension combined with penetrating high kilovoltage roentgen exposure.[6] Dilute suspensions of barium might also be used advantageously in the examination of the stomach where detection of small filling defects is likewise rendered difficult by dense overlying contrast medium.

Water soluble contrast media are still too expensive and too unpalatable to permit their routine use in the examination of the stomach or the colon, but limited experience suggests that in this direction lies the probable "ideal" gastrointestinal contrast medium—dense enough to fill craters and out-pouchings, radiolucent enough to leave filling defects unobscured, voluminous enough to distend organs, fluid enough to pass narrow areas in the intestine completely, inert, and inexpensive. The gastrointestinal radiologist is still awaiting this contrast medium.

Skill. An anxious patient perfunctorily ushered into the dark fluoroscopic room represents a real challenge to the radiologist. To achieve cooperation and inspire confidence under these circumstances requires all the skill as a physician that the gastrointestinal radiologist can muster. If he fails and becomes merely a voice in the dark or remains a silent appendage of the mechanism which surrounds the apprehensive patient, much will be lost. Aside from the social and public relations aspects of such a performance on the part of the radiologist, there is a real necessity for skillful handling of his patient. It is well accepted, for instance, that stress and emotion have a definite effect on the gastrointestinal tract[7] and the cautious radiologist considers seriously these factors and the ways to avoid them.

Whereas twenty years ago the middle age groups constituted the greatest number of subjects for gastrointestinal examination, lately more and more representatives of the two extremes of the age scale present themselves for examination. Infants, children, and geriatric patients now come under the scrutiny of the radiologist and they all require gentle and sympathetic handling. The skill or art of gastrointestinal radiology cannot be acquired from textbooks or by trial and error, but must be slowly learned by watching older, more experienced radiologists in their relationship with patients.

Modern equipment and variegated techniques are all essential in gastrointestinal radiology, but only the skill of the physician-radiologist can make the modern gastrointestinal examination a satisfactory experience for both the examiner and the patient.

Harold Fulton, M.D.

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We regret to announce the death on March 2, 1957, of Dr. B. R. Kirklin, a distinguished member of the American Roentgen Ray Society.

SOCIETY PROCEEDINGS AND NEWS ITEMS*

RADIOLOGIC PHYSICS COURSE LEADING TO DEGREE OF MASTER OF SCIENCE

The College of Physicians and Surgeons of Columbia University announces a course in radiologic physics, leading to the degree of Master of Science, to be given during the academic year 1957–58. This is a full-time, integrated course, including lectures, seminars, conferences, and laboratory work. The faculty are members of the Department of Radiology. Drs. Quimby, Rossi, Rugh, Braestrup, Feitelberg, and Gross will cover different phases of radiologic physics and radiobiology, while Drs. Seaman and Kligerman will present clinical applications. Practical laboratory work will be stressed, a large number of experiments being planned to cover all aspects of the course.

Prerequisite for admission is a bachelor's degree, with a major or very strong minor in physics, or equivalent scholastic background, with a good academic record. Tuition for the complete course is $900.

Inquiries may be directed to Dr. Edith H. Quimby or Dr. Harald H. Rossi, 630 West 168th Street, New York 32, New York.

FELLOWSHIP IN RADIOLOGICAL PHYSICS

Applications are now invited for matriculation commencing this fall in the graduate radiological physics program in the Sloan-Kettering Division of Cornell University Medical College. The program includes training in various aspects of implant dosimetry, treatment planning, calibration and measurement of different energies of x-rays and electrons, radioisotope handling, diagnostic and therapeutic aspects of radioisotope use, and radiation protection procedures. This training together with other courses and a thesis problem constitute the primary requirements for the master of science degree. Fellowship aid which covers living and tuition expenses is available. For more information please write Dr. John S. Laughlin, Department of Physics, Memorial Center, New York 21, New York.

DR. JOHN A. CAMPBELL TO DELIVER FREEDMAN LECTURES

On Saturday and Sunday, April 13 and April 14, 1957, Dr. John A. Campbell, Chairman, Department of Radiology of Indiana University Medical Center will deliver the ninth Annual Joseph and Samuel Freedman Lectures in Diagnostic Radiology at the University of Cincinnati College of Medicine. Radiologists desiring to attend are requested to write Dr. Benjamin Felson, X-ray Department, Cincinnati General Hospital, for further details.

ROCKY MOUNTAIN RADIOLOGICAL SOCIETY

The next annual midsummer meeting of the Rocky Mountain Radiological Society will be held in Denver at the Shirley-Savoy Hotel on August 15, 16 and 17, 1957.

SOUTHERN RADIOLOGICAL CONFERENCE

Recently the Alabama and Mississippi Radiological Societies held a joint meeting to organize the Southern Radiological Conference. The new group includes radiologists from Mississippi, Alabama and Northwest Florida and is accepting charter members through June 1, 1957. Qualified radiologists interested in membership may apply to the Secretary-Treasurer, Dr. Marshall Eskridge, Mobile Infirmary, Mobile, Alabama. Dues are $10.00 per year.

* The list of Meetings of the Radiological Societies appears in the March, 1957, issue of the Journal, and will be published in the May number.

Vol. 77, No. 4

ABSTRACTS OF RADIOLOGICAL LITERATURE

Department Editor: T. Leucutia, M.D., Harper Hospital, Detroit 1, Michigan

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ROENTGEN DIAGNOSIS

Head

Psenner, L. Beitrag zur Röntgensymptomatologie der raumbeengenden Prozesse der Orbita. (Contribution to the roentgen manifestations of space-occupying processes of the orbits.) *Fortschr. a. d. Geb. d. Röntgenstrahlen u. d. Nuklearmedizin*, Aug., 1956, *85*, 125–141. (Address: Alserstr. 4, Wien IX, Austria.)

Exophthalmus may be caused by processes originating in the orbit, in neighboring structures, or more distant intracranial locations. Some cases of exophthalmus show no roentgenologic diagnostic features, e.g., during vicarious menstruation, thyrotoxicosis, fibrosis of retrobulbar fat, and retrobulbar lymphatic stasis. However, a large group of conditions can be identified roentgenographically even without the aid of contrast media in the vessels or air in the ventricular system. In general, the roentgen features consist of abnormal calcifications, such as in retinal gliomas, intra-orbital hemangiomas, and chondromas; generalized enlargement of the bony orbit with corresponding thinning of the walls, which is usually associated with a benign expanding tumor in adults, whereas similar changes in children may be due to an intra-orbital sarcoma; localized erosions, single or multiple, the former being benign when well-defined and smooth in outline but malignant when the outline is irregular, whereas multiple areas suggest the possibility of hemangiomas; and new bone formation, which occurs chiefly in meningiomas or in osteo-angiomas and rarely in sarcomas. Increased density within the orbit may be due to an increase in the intra-orbital soft tissues or a thickening of the osseous structures. The contrast between the superior orbital fissure and its osseous borders is decreased in the former instance and increased in the latter.

Intraorbital Conditions. These may be due to inflammation or tumor formation. (A) Among the inflammatory conditions are those due to direct infection, either traumatic with or without the presence of a foreign body or those following surgical intervention; embolic-metastatic inflammations, e.g., in puerperal fever, septicemia, and pyemia; and inflammations secondary to blepharitis, dacryocystitis, sinusitis, as well as infections of the mouth, pharynx, and cavernous sinus.

Another type resembling an inflammatory condition is the so-called pseudotumor, which histologically is composed of lymphoid cells in follicular arrangement, hyaline degeneration of vessel walls, and numerous plasma cells, somewhat similar to tuberculous lesions but in which acid-fast bacilli have never been found; occasionally, the lesions resemble the lymphatic hyperplasia of Mikulicz's disease.

The roentgen appearance of these conditions is frequently negative but they may cause a slight uniform enlargement of the orbit. The choice of treatment is radiation therapy.

(B) Soft tissue tumors of the orbit are benign or malignant. The former include hemangioma, lymphangioma, neurocytoma, neurinoma, fibroma, lipoma, and myoma. From a roentgenologic standpoint only the hemangiomas and optic nerve gliomas contain calcifications or produce erosions of bone to make them diagnosable; the other tumors may show no diagnostic roentgen signs or may produce a generalized or localized enlargement of the orbit, when the smooth character of the enlargement points to the benign nature of the tumor. Calcifications in hemangiomas usually produce small, round or oval shadows; the bony erosions are small, round or slightly elongated and are scattered over small or larger areas, usually more intensive in the central than in the peripheral portions of the hemangioma. In rare cases a hemangioma may produce a generalized, smooth enlargement of the entire orbit. Incidentally, varices may also produce an exophthalmus. Alterations of the optic canals are easily seen in the special views of this region. Tumors of the lacrimal gland cause a typical thinning of the roof of the orbit with a sharp, smooth border in the outer and upper quadrant of the orbit.

Malignant tumors of the soft tissues are most often sarcomas, e.g., fibromyxosarcoma, spindle cell sarcoma, and reticulum cell sarcoma. A few squamous cell carcinomas have been reported. Malignant tumors may not be recognizable roentgenographically until the adjacent bone is involved.

Diseases of the Bony Orbit. (A) The benign tumors of the orbital wall include osteoma, osteo-angioma, chondroma, myxochondroma, epidermoid, and dermoid. Osteomas are recognized by their dense compact shadows. They usually arise from the paranasal sinuses and secondarily invade the orbit. Osteo-angiomas are characterized by small, round or elongated radiolucencies within a dense mass and frequently are indistinguishable from meningiomas. Chondromas and myxochondromas present rounded radiolucencies which are separated from each other by fine septa resembling a network; the border of the mass is represented by a lobulated but clearly defined line which separates the tumor from the adjacent normal bone. Epidermoids and dermoids arise near sutures and clefts, e.g. where the greater wing of the sphenoid meets the frontal process of the zygoma; the tumors expand eccentrically, and have a sharp, wavy, sclerotic border, and contain bony trabeculations or give rise to branch-like, peripheral extensions.

Eosinophilic granulomas arise as a solitary focus but in one to two years may become multiple and scattered over a large area, especially in children and young adults. These tumors usually have very wavy borders with sharp outlines or poor demarcations from the normal bone. They frequently occur in the

dura but also in the region of the orbits and paranasal sinuses.

(B) Malignant tumors may be metastatic or primary sarcomas and carcinomas. The defects caused by carcinomas, usually in the anterior and superior margins of the orbit, are uncharacteristic; but occasionally numerous small, poorly circumscribed rarefactions indicate the multiple infiltrating centers of growth. The sarcomas produce hyperostotic changes within the tumor zone and osteoporosis in the adjacent bone. The latter resemble the findings seen in tuberculosis. Reticulum cell sarcomas are generally large, involve both tables of the skull, and penetrate into the soft tissues. Thus spiculation is a characteristic feature of these tumors; the spicules are invariably broad and quite dense.

(C) Among the chief inflammatory lesions are osteomyelitis and tuberculous caries. The former is frequently metastatic or secondary to sinusitis. The resulting defects are uncharacteristic but the roentgenograms help determine the extent of the lesion while its nature is diagnosed clinically.

Extraorbital Conditions. (A) The paranasal sinuses: Infections may spread to the orbits and cause bone destruction. Mucoceles, which occur chiefly in the frontal sinuses, may become quite large and cause displacement of adjacent tissues. This displacement differentiates them from expanding, malignant tumors, which are invasive. Because of their own radiolucency, they may even be more radiolucent than the contralateral sinus. Of the benign tumors, only the fibromas cause displacement and destruction of the orbital walls. Malignant tumors produce considerable bone destruction but rarely cause exophthalmus.

(B) Anterior Cranial Fossa: Meningoceles and encephaloceles occur in the midline, especially at the cribriform plate, enlarge symmetrically to both sides, rarely produce exophthalmus, and give rise to hypertelorism. However, when these tumors arise in the orbital roof or near the superior orbital fissure, exophthalmus develops. Benign tumors, such as dermoids and epidermoids, occasionally break through into the orbits and cause exophthalmus. Malignant tumors of this region, as elsewhere, cause extensive destruction.

(C) Middle Cranial Fossa: The most frequent tumor is the meningioma of the wings of the sphenoid. It is characterized by marked hyperostosis and extensive bone destruction. The latter includes involvement of the parasellar region, alterations of the clinoid processes, enlargement of the sella, widening of the superior orbital fissure, optic canals, and foramina at the base of the skull. Rarely an aneurysm of the internal carotid will cause extensive destruction, but a differential diagnostic point is that the aneurysm which involves the optic canal will cause a defect on the outer and inferior margin of the canal.

(D) Epipharynx: Enlarged adenoids may produce lymphatic stasis in the retrobulbar tissues and then exophthalmus. Epipharyngeal tumors may extend through the superior orbital fissure and cause exophthalmus.

(E) Intracranial lesions at a distance from the orbits may cause exophthalmus by pressure on the cavernous sinus, and subsequent venostasis in the orbit. The exophthalmus in acromegaly may be produced in the the same manner, although some attribute the change to an increase in orbital adipose tissue.—*J. Zausner, M.D.*

Holmes, Francis H. Mandibular block by osteochondroma of the coronoid processes. *Radiology*, Oct., 1956, *67*, 578–581. (Address: U. S. Naval Hospital, Great Lakes, Ill.)

Two cases of osteochondroma of the coronoid processes of the mandible are presented. There is a paucity of reports of this condition in the literature and the diagnosis is easily missed on routine roentgenography. A submento-vertex projection with the head slightly tilted to the unaffected side gives a definitive view which is sufficient for the diagnosis, but laminagraphy provides a more exact study of the coronoids without distortion.

The 3 cardinal points in osteochondroma of the coronoid process are: progressive blocking of mandibular movement, painless and usually beginning at about the age of fourteen; inequality of movement of the mandible on the two sides; and enlargement of the tip of the coronoid process found by intra-oral digital examination. With awareness of the condition and proper roentgenographic examination, a disabling condition may be cured by simple surgical means.—*Harold C. Hamilton, M.D.*

Lepp, F. H., and Berning, H. P. Zur röntgenologischen Differentialdiagnose progressiver, intradentärer Resorptionsprozesse am bleibenden Gebiss. (The roentgenologic differential diagnosis of progressive, intradental resorption in permanent teeth.) *Fortschr. a. d. Geb. d. Röntgenstrahlen u. d. Nuklearmedizin*, Aug., 1956, *85*, 159–174. (From: Cátedra de Clínica Estomatológica, Facultad de Odontología de la Universidad Nacional del Zulia and Departamento de Rayos X, Hospital Quirúrgico y Maternidad, Maracaibo, Venezuela.)

The differentiation between the central and peripheral types of resorption within the tooth is essential to proper therapeutic management. For greater accuracy, intra-oral roentgenograms with eccentric direction of the rays are highly important. Internal resorption is a centrifugally progressive, fairly symmetric process and appears as a round, oval, or spindle-shaped defect. External or periph-

eral resorption arises from the parodontal zone, and is centripetally progressive, infiltrative, asymmetrically expansive, and, most characteristically, does not involve the root canal, which is fairly clearly seen superimposed through the eccentric defect. The authors also point out that certain reparative changes in the course of the peripheral type of resorption leave a peculiar trabeculation within the osteolytic defect, thus masking the true extent of the pathology.

Internal resorption may be classified according to location, as coronal, radicular, or apical. External resorption (extracanalicular) may be divided into the marginal or apical types, each being further subdivided into the approximal and oral or vestibular varieties.—*J. Zausner, M.D.*

Neck and Chest

Ware, Paul F., and Stauss, Hans-Karl. Lung expansion patterns following upper lobe segmental resection. *Radiology*, Oct., 1956, *67*, 516–526. (Address: P. F. Ware, 16 Norwich St., Worcester, Mass.)

A series of 50 patients who had undergone upper lobe segmental resections for pulmonary tuberculosis were studied in relation to the expansion of the lung remnant postoperatively. The expansion patterns were determined by attaching dural clips to the edges of the segmental defects, major and minor fissures, and the superior segment of either lower lobe during surgery.

Knowledge of the pattern of pleural space-filling by the remaining segments of the lobe aids in the early and late postoperative management of these patients. Partial or complete atelectasis or hematoma of segments adjacent to the resection defect are readily seen. The necessity for thoracentesis, insertion of a polyethylene catheter or chest tube, a modifying thoracoplasty or re-exploration can be determined by the location of the dural clips. These clips also define the area of linear fibrosis due to operation and prevent subsequent error in evaluation of reactivation or spread. The parenchymal rearrangement following these segmental resections is more or less constant, with the ultimate pattern well established by the end of the third postoperative week. Minimal changes may occur up to the end of the sixth postoperative month.

Representative cases are illustrated to show the various expansion patterns following the different segmental resections—*Donald N. Dysart, M.D.*

Parks, Raymond E. Traumatic torsion of the lung; case report. *Radiology*, Oct., 1956, *67*, 582–583. (Address: Jackson Memorial Hospital, Miami 36, Fla.)

A case of torsion of the left lung following trauma to the left lower chest is presented. A seven year old white girl fell from a moving vehicle and a front wheel passed over the lower chest anteriorly. The initial roentgenogram of the chest showed curved linear densities extending from the left hilus upward to the apex due to inverted vascular trunks. Laparotomy twelve hours after admission, revealed extracapsular rupture of the spleen and retroperitoneal hemorrhage, and splenectomy was performed. Chest roentgenograms, made on the second and third hospital days and subsequently, showed homogeneous clouding of the left chest which was assumed to represent a massive hemothorax. Left thoracotomy six weeks after admission revealed the lung to have rotated 180° in a clockwise direction, viewed from the lateral to the medial aspect. All segments of the left lung except the superior segment of the lower lobe showed evidence of gangrene and were resected. The patient had fully recovered from all injuries six months after the accident.

This case was strikingly similar to the case reported by Stratemeier and Barry in 1954, which was the first case recorded in medical literature of torsion of the lung following trauma.—*Harold C. Hamilton, M.D.*

Buenger, Richard E., Paul, Oglesby, and Fell, Egbert H. Calcified polyp of the heart. *Radiology*, Oct., 1956, *67*, 531–536. (Address: R. E. Buenger, Presbyterian Hospital, 1753 West Congress St., Chicago 12, Ill.)

A calcified polypoid tumor of the heart in a boy of sixteen is reported. Roentgenographic examination of the chest showed moderate cardiac enlargement, most evident in the region of the right atrium and ventricle. The tumor was recognized and localized fluoroscopically, moving back and forth through the tricuspid valve with each cardiac cycle. Calcification of the periphery of the polyp was sufficient for fluoroscopic visualization of the tumor, and preoperative diagnosis.

Presence of the polypoid tumor, attached by a pedicle 1.0 cm. in diameter to the right atrial wall, was confirmed at surgery. An attempt at removal was made, but the patient died.—*A. W. Sommer, M.D.*

Abdomen

Catel, W., and Garsche, R. Studien bei Kindern mit dem Bildwandler. I. Mitteilung: Anatomie und Motilität des distalen Ösophagus-Abschnittes. (Studies in children with the image amplifier. Part 1. Anatomy and motility of the distal esophageal segment.) *Fortschr. a. d. Geb. d. Röntgenstrahlen u. d. Nuklearmedizin*, July, 1956, *85*, 1–11. (From: Univ.-Kinderklinik, Kiel, Germany.)

The advantages of the image amplifier are: (1) Improvement in diagnosis with decrease of exposure

to patient; (2) considerable increase in luminosity of the screen image; and (3) possibility of exact functional diagnosis by cinematography.

In concurrence with the impressions of Lerche and others, the authors' studies suggest that the distal segment of the esophagus, from anatomic and functional viewpoints, must be considered in 3 parts:

1. Cardia inferior. This, the true cardia, is the site of opening of the esophagus into the stomach. A constrictor muscle (constrictor cardiae) is found here, the existence of which is questioned by some authors.

2. Antrum cardiacum (gastroesophageal vestibule). This begins immediately above the cardia inferior and extends cephalad through the diaphragm to that area where the muscle of the inferior esophageal sphincter is seen.

3. Cardia superior. This is at the cranial end of the antrum.

In contrast to older children and adults where the esophagus forms a sharp angle to the left at the level of the 8th thoracic vertebra, this was not true in those children under one year of age. In these young babies, the esophagus assumes a perpendicular course to the cardia.

Others have attributed a milking action of the diaphragm to the distal end of the esophagus. This could not be confirmed by the present studies and it was found that the active transmission of fluids occurred because of the action of the smooth muscle of the esophagus. It was demonstrated that after a swallow of the material entered the stomach, the cardia superior and inferior, which were now empty, showed spontaneous synchronous opening and closing movements. These may be due to change in tone and not to true contraction of the muscle fibers. Peristaltic waves were never seen in infants and children of different ages. The distal segment of the esophagus assumes 3 different forms during the emptying process:

1. *Primitive form.* The progress of the material through the most distal portion of the esophagus into the stomach is such that, after a certain filling pressure has been attained in the region above the ampulla (cardia superior), the latter relaxes and simultaneously with it, the smooth muscle of the antrum and cardia inferior also relaxes.

2. *Hypertonic form.* The relaxation of the smooth muscle in the region of the cardia superior and inferior which leads to the emptying of the food into the stomach, is associated with an increase in tone in the region of the ampulla. This form has been designated previously by the authors as hypertonic-atonic dysphagia.

3. *Mature form.* The first 2 forms are regularly seen in infants. Beginning with five year old children, however, the emptying mechanism of the distal end of the esophagus assumes that seen in youths and in adults. In this third form the food passes through the cardia superior, antrum, and cardia inferior in a continuous stream.

The first 2 types of action are probably due to intramural reflex mechanisms while the vagus is responsible for the third type. By the use of the image intensifier, it has been possible for the first time to make exact measurements of the duration of the single peristaltic phase of the distal end of the esophagus. For example, in a four month old infant, the active phase lasted 7/16th and the interval phase 10/16th of a second.

All examinations were carried out with the baby suspended in a special holder to facilitate fluoroscopy and to immobilize the patient.—*Samuel Richman, M.D.*

Klinefelter, Edmund W. Invagination of the esophagus in hiatus hernia. *Radiology*, Oct., 1956, *67*, 562–567. (Address: 546 W. Market St., York, Pa.)

Three case reports, and roentgenograms of these patients, are presented to illustrate a condition designated by the author as invagination of the esophagus in hiatus hernia. Dysphagia occurs in over half of the patients who present this appearance. Pain, in the form of pressure or discomfort behind the lower sternum, is present in some patients. Symptoms tend to be intermittent and nonprogressive. Why the upward protruding stomach in hiatus hernia should at one time displace the esophagus upward, and at another time ensheath it, has not been explained.

Diagnosis depends upon adequate study of the esophagogastric region by fluoroscopy and spot films, with the patient in the horizontal, semihorizontal, and vertical positions.—*A. W. Sommer, M.D.*

Bradley, Robert L., Short, Eugene H., and Klein, Michael M. Leiomyoma of the jejunum with hemorrhage. *Radiology*, Oct., 1956, *67*, 576–577. (Address: R. L. Bradley, VA Hospital, 1540 Spring Valley Dr., Huntington 1, W. Va.)

Although smooth muscle tumors of the gastrointestinal tract are uncommon, awareness of this type of lesion and its behavior is important because of the favorable prognosis. These tumors may be subserosal, intramural, or submucosal. The submucosal lesions may ulcerate and bleed or may lead to intussusception. Intramural lesions are most commonly incidental autopsy findings, and subserosal tumors produce symptoms only when relatively large. The malignant tumors of this group grow slowly and metastasize late, and surgical excision affords a high percentage of cures. A case of leiomyoma of the jejunum with ulceration, in which the presenting symptoms were due to the anemia resulting from hemorrhage, is presented.—*Harold C. Hamilton, M.D.*

Gannon, William E., and Harrington, Leo A. Volvulus of the entire small bowel in the immediate postoperative period. *Radiology*, Oct., 1956, *67*, 569–572. (Address: W. E. Gannon, Kings County Hospital, 451 Clarkson Ave., Brooklyn 3, N. Y.)

Volvulus of the entire small intestine is a comparatively rare entity which is usually seen in children and is due to some congenital abnormality. It does, however, sometimes occur in adults, and in such instances is most commonly the result of postoperative adhesions. Rarely the condition is seen in adults in the immediate postoperative period. The authors suggest that in such instances the volvulus may develop as a result of inadvertent rotation of the small intestine by the hand of the surgeon through an arc of 180 degrees or more during palpation of the abdominal contents through a small incision.

The case report of a thirty year old white female who developed volvulus of almost the entire small intestine in the immediate postoperative period following removal of the appendix through a small incision is presented. This patient tolerated the operative procedure well, but the next day went into shock. Following recovery from the shock, abdominal distention and an epigastric mass were noted. The patient's general condition improved, but she continued to have episodes of jaundice, pain, distention, and toxic psychosis. Plain roentgenograms revealed a large amount of gas in what appeared to be a a hollow viscus in the mid abdomen. Gastrointestinal study showed that barium entered the gas-containing cavity and later re-entered the distal small bowel to reach the colon. At surgery, a large abscess completely filled the lower two-thirds of the abdomen. The abscess cavity contained many ounces of undigested food and a stringy necrotic cast of the small bowel. A duodeno-ileostomy was performed, followed by death on the fifth postoperative day.

The case reported here is unique in respect to the length of survival following occurrence of the volvulus. Early operation in cases of acute volvulus of the intestine is usually considered imperative. This patient, however, lived thirty-eight days before the second operation, apparently because the necrotic bowel was sealed off by the omentum.

The fact that a correct diagnosis was not made preoperatively in this patient is not surprising, as it has been shown that a diagnosis of volvulus of the small bowel is always difficult because of the lack of a characteristic syndrome.—*A. Ralph Watson, M. D.*

Engelhardt, Jack E., and Jacobson, George. Infarction of the colon, demonstrated by barium enema. *Radiology*, Oct., 1956, *67*, 573–575. (Address: J. E. Engelhardt, St. Joseph Hospital, Orange, Calif.)

This article is a case report of inferior mesenteric thrombosis demonstrated by barium enema. A barium enema study was undertaken in this patient because of the possibility of mechanical obstruction. This revealed the colon in the region of the splenic flexure to be markedly narrowed and stiff, with thick edematous mucosa, almost polypoid in appearance. The mid transverse colon and descending colon were slightly narrowed, with minimal irregularity of the wall. Postmortem examination revealed an infarction of the left half of the transverse colon, including the splenic flexure, and about a third of the descending colon. Multiple organizing, recently formed, clots were present in the inferior mesenteric artery which supplies this area of the colon.

Occlusion of the lumen occurs much more frequently in the superior mesenteric artery than in the inferior artery. This is due to its larger size, its higher point of origin from the abdominal aorta, and the fact that it comes off almost parallel to the latter, while the inferior artery comes off at nearly a right angle and is thus less likely to intercept an embolus. Since the inferior vessels are not terminal and have a collateral circulation with other vessels, the clinical picture is usually less acute and more confusing than when the superior vessels are involved, when a picture of an "acute surgical abdomen" is present.—*Donald N. Dysart, M.D.*

Jacobs, Lewis G., Gerstl, Bruno, Hollander, A. Gerson, and Berk, Morris. Intra-abdominal egg-shell calcifications due to silicosis. *Radiology*, Oct., 1956, *67*, 527–530. (Address: L. G. Jacobs, 411 Wayne Ave., Oakland 6, Calif.)

The authors have presented a case of silicosis in which egg-shell calcifications were present in both the thoracic and abdominal periaortic lymph nodes. This appears to be a rare complication.

In persons with silicosis, two types of calcification are commonly found in the lungs, hili, and adjacent lymph nodes. One, an irregularly amorphous calcification of the lymph nodes involving much or all of the central portion of the lymph node, is referred to as the "mulberry" type because of its appearance; the other, a peripheral calcification of the lymph node in a thin layer, is called the "egg-shell" type. Apparently sarcoidosis can sometimes cause the same "egg-shell" type of lymph node calcification.

Silicotic calcification may also be found in the abdomen as a result of lymphatic drainage from the chest. Centripetal lymphatic drainage from the pulmonary periphery to the pleura and diaphragm is a normal occurrence and may be accentuated in pneumoconiosis because of occlusion of the mediastinal lymph channels by fibrosis. Communication with the preaortic lymph nodes via the lymph

channels in the pulmonary ligament has not been proved in man, but it would be speculative to assert that it could never occur. Mulberry calcifications, microscopic in dimension, are a common finding in the liver, spleen, and hili of these organs, and in the surrounding lymph nodes in autopsies of silicotic individuals. On the other hand, egg-shell calcifications in the abdomen due to silicosis are exceedingly rare. A fairly extensive review of the literature revealed only one previously reported case.

Nonsilicotic egg-shell calcifications may sometimes be found in the abdomen. Calcifications of this type occasionally occur secondary to hematoma and also may be observed within the walls of a hydatid cyst.

The patient whose case was reported in this article died of cardiac failure. The calcified abdominal lymph nodes did not appear to contribute to the clinical picture.—*A. R. Watson, M.D.*

SKELETAL SYSTEM

RASPF, R. Ein neues Verfahren zur Herstellung von Röntgen-Ganzaufnahmen der Wirbelsäule ("3-Phasen-Technik"). (A new roentgenographic technique of the entire spinal column ["3-phase-technique"].) *Fortschr. a. d. Geb. d. Röntgenstrahlen u. d. Nuklearmedizin*, July, 1956, *85*, 106–110. (Address: West-Sanatorium, Joachimstaler Strasse 21, Berlin W. 15, Germany.)

The author describes a technique for roentgenography of the entire spine on one film with the patient upright and at a long target-film distance. The various sections of the spine, cervical, thoracic, and lumbar, are roentgenographed separately but appear on the film as a continuous unit ("3-phase-technique").

At a focus-film distance of 2 to 3 meters, the holder containing a long cassette is placed behind the upright patient, with the central ray directed at the level of the tenth thoracic vertebra. A movable grid is located in front of the cassette and is positioned behind that portion of the spine which is roentgenographed in 3 successive exposures from the cervical down to the lumbar area. When 1 portion of the spine is exposed, the other 2 are protected by proper adjustment of light sight. The slight overlapping of the 3 exposures does not spoil any of the films. The patient, film, and tube must not be moved during the 3 phase exposure.

It is necessary to have a lead diaphragm in front of the roentgen tube, which diaphragm is set into small, oscillatory movements during each roentgen exposure and thus the overlapping of the spine segments obliterated. This diaphragm consists of 2 opposing movable lead plates, the opening between which is adjusted for each exposure. The oscillatory movements of the frame of the diaphragm are made possible by the presence of wire springs attached to the upper and lower ends of the frame.

In the anteroposterior projection of the spine (at 3 meters target-film distance), the patient receives a total dose of 18 r, and in the lateral projection about 12 to 15 r.—*Samuel Richman, M.D.*

DREIFUSS, F. E. Bone changes in hemiplegia of early onset. *Brit. J. Radiol.*, Nov., 1956, *29*, 601–604. (From: The National Hospital, Queen Square, London W. C. 1, England.)

The author correlates the physical findings in 50 patients suffering from hemiplegia of early onset with the roentgengraphic appearance of the skull and long bones and attempts to evaluate the possible influence of loss of power and sensation on the growth of these structures.

The age of onset of the hemiparesis and the length of time the patient had been hemiplegic did not seem to be significant to the development of bony lesions as long as the onset was before the growth of the skull slowed up after puberty. The main lag in growth occured in the early years following the hemiparesis.

There was no correlation between skull changes and the clinical severity of the hemiplegia. The order of reliability of roentgenographic changes in the skull was vault asymmetry, thickness of the vault, and size of the frontal sinuses. These signs alone, or in combination, were present in 86 per cent of patients. The size of the ethmoid air cells and of the middle fossa were too variable to be reliable guides, although the latter was the only roentgenographic abnormality in the skull in 6 per cent of the patients.

Some changes in the long bones were present in 49 of 50 patients, the most involved bones being the humerus, ulna and radius. The epiphyses involved chiefly were those at the elbow and wrist. Changes in bone thickness and density and the relative proportion of the cortex and medulla tended to follow changes in length, but were more variable and less reliable than differences in length.

Correlation of bony changes with clinical signs revealed, in general, that agenesis tended to parallel the loss of power. Where sensory loss predominated there was less agenesis than there was motor loss, which was the significant finding. The greatest changes occurred where there was both motor and sensory involvement.

The author concludes that agenesis can be accounted for by disuse during the growth period. The effect of sensory loss then would be to augment the disuse, for an astereognostic limb is used less than a solely weak one.—*Frank J. Rigos, M.D.*

PORSTMANN, W. Spondylitis infectiosa im Anschluss an Verletzungen des vorderen Längsbandes. (Beitrag zur Spondylitis nach Paravertebralanästhesie). (Infectious spon-

dylitis as a result of injury to the anterior longitudinal ligaments. [Contribution to spondylitis subsequent to paravertebral anesthesia].) *Fortschr. a. d. Geb. d. Röntgenstrahlen u. d. Nuklearmedizin*, July, 1956, *85*, 66–75. (From: Universitäts-Röntgeninstitut der Charité, Berlin, Germany.)

In reviewing previously published cases of spondylitis after paravertebral anesthesia, the same clinical and roentgenologic findings were noted. Nearly all the patients complained of back pain one to two days after the paravertebral anesthesia. In some cases the pain occurred immediately after the completion of the injection. Sometimes, there was local swelling at the site of the injection. More frequently, the complaints were referable to meteorism and ileus. Local pressure pain over the spinous process occurred later. Shortly after the paravertebral anesthesia there was a fever of about 100° F., which remained for several days to weeks, sometimes with remissions. Roentgen findings were noted from three weeks to nine months after the onset of clinical signs, mostly within two months. An early roentgen diagnosis was never possible. In the presence of marked subjective symptoms with the absence of objective findings, a diagnosis of psychoneurosis usually was made.

The earliest recognizable roentgen findings were in the vertebral body. These consisted of haziness, loss of structure, and erosions of the superior, inferior, and anterior margins of the vertebral body. Simultaneously, there was frequently a decalcification of the involved vertebra. The intervertebral disks were always involved later, being narrowed or destroyed. These were normal in the early stages, when the erosion of that surface of the vertebral body adjacent to the intervertebral disks was already noted.

On the basis of 3 personal cases and on review of 12 others published in the German literature, the following characteristics of infectious spondylitis after paravertebral anesthesia, in contrast to hematogenous infectious spondylitis after an infectious disease, can be demonstrated:

1. Extension of the process over a large segment of the vertebral column is frequent. In hematogenous spondylitis, the process is limited to 2 and at most to 3 vertebral bodies.

2. The intervertebral disks and adjacent surfaces of the vertebral bodies are always involved. The nature of spread of the process leads to the conclusion that the infection advances under the anterior longitudinal ligament.

3. Large loss of substance of single vertebral bodies has not been observed. On the contrary, the intervertebral disk may be destroyed completely.

4. A paravertebral abscess has never been reported.

5. Rapid onset of reparative processes (sclerosis and smoothening of the erosions) rule out tuberculous spondylitis.

6. Healing occurs in an average of nine months with fibrotic ankylosis of the involved vertebral segment or, in case of incomplete destruction of the intervertebral disks, with bridging by formation of spurs.

7. The roentgen diagnosis is established usually within two months after paravertebral anesthesia. The early roentgen finding is a haziness of those surfaces of the vertebral body adjacent to the intervertebral disk. Later the disks are always flattened.

8. Findings such as fever, meteorism, leukocytosis, and rapid sedimentation rate always recede. In many cases, localized pain at site of injection may last for several hours to several days.—*Samuel Richman, M.D.*

Blood and Lymph System

Broadbridge, A. T. Hypaque in cerebral angiography; a clinical assessment of its merits in relation to sodium acetrizoate (diaginol) and diodone. *Brit. J. Radiol.*, Nov., 1956, *29*, 577–584. (From: St. George's Hospital Neuro-Radiological Department, Atkinson Morley Hospital, Wimbledon, London, S. W. 20., England.)

The author reviewed the results of 200 cerebral angiographies done on each of 3 groups of patients, using a different contrast medium in each group. There were 200 anteriographies in which diaginol 25 per cent, 200 in which hypaque 25 per cent, and 200 in which diodone 35 per cent was used In these 600 arteriographic examinations, there was an average of 1.2 punctures and 3.6 injections per artery. An approximate average of 31 cc. of contrast medium was injected into each artery.

Adequate contrast density was obtained with hypaque 25 per cent, in 95 per cent of the arteriograms. A more concentrated solution was needed in 5 per cent. Since then, 35 and 45 per cent hypaque have been used with good contrast.

Hypaque 25 per cent causes little sensation in the majority of patients. With more concentrated solutions, about half the patients note a sensation of cold, and the other half one of warmth. It was the author's impression that the nearer the temperature of the solution was to the blood temperature the less the sensation experienced by the patient.

No severe allergic reaction was encountered with any of the 3 substances, and there was no significant difference in the incidence of complications with the 3 media.

Hypaque was considered to be the most satisfactory of the 3 contrast media for cerebral angiography. It is virtually free from discomfort and does not require the use of anesthesia. Hypaque also produces less damage to the blood-brain barrier of

rabbits than either diodone or sodium acetrizoate.

It is concluded that hypaque is a good contrast medium for cerebral arteriography. The 45 per cent solution in most cases gives excellent contrast and is apparently as safe as the more dilute solutions. Therefore, it is the concentration of choice.—*Frank J. Rigos, M.D.*

Whiteleather, J. E., and DeSaussure, R. L. Experience with a new contrast medium (hypaque) for cerebral angiography. *Radiology*, Oct., 1956, *67*, 537–543. (Address: J. E. Whiteleather, 899 Madison Ave., Memphis 3, Tenn.)

Over 300 carotid or vertebral angiographies have been done using a 50 per cent aqueous solution of hypaque sodium (sodium 3,5 diacetamido-2,4,6-triiodobenzoate) which contains 59.87 per cent iodine. This contrast medium proved to be no more irritant or toxic than diodrast and it provided superior contrast even with 10 cc. (one-half the dosage of diodrast). Fewer side-effects such as nausea, allergic reactions, subjective complaints, etc., were noted.

Prior to its clinical use extensive studies were carried out on dogs, the details of which are presented in this paper. Other contrast media, such as urokon sodium in 30 and 50 per cent solutions, were also used but were found less desirable or undesirable because of greater toxicity. Miokon sodium 50 per cent and renografin 76 per cent have been tested in dogs and, while these media show promise, testing has been incomplete and no clinical studies have as yet been made.

It is the opinion of the authors that hypaque sodium 50 per cent aqueous solution provides a better diagnostic quality of films, and that observers have been able to arrive at diagnostic opinions with more certainty.—*Donald N. Dysart, M.D.*

Basu, A. K., and Das, A. Splenoportal venography for evaluating abnormalities of portal circulation. *Brit. M. J.*, Oct., 1956, *2*, 916–919. (From: Nilratan Sircar Medical College, Calcutta, India.)

A series of 46 successful splenoportal venographies were performed by percutaneous injection into the splenic pulp. Most of these patients were subsequently operated upon and the splenoportal circulation could be correlated from the venogram and the actual anatomic findings, pressure measurements, and the histologic pattern.

Four characteristic venographic patterns were found. The first pattern was noted in tropical splenomegaly of uncertain origin uncomplicated by cirrhosis. The splenic and portal veins were very dilated and tortuous, collaterals were not present in any case. The bifurcation of the portal vein was well seen and the intrahepatic radicals were faint and indistinct.

The second pattern was present in infrahepatic obstruction of the portal venous system. In splenic vein obstruction the contrast medium terminated abruptly, whereas in cavernomatous transformation of the portal vein, the contrast medium became diffusely distributed over numerous small tortuous channels. In both cases many collaterals were present.

The third pattern was found in intrahepatic obstruction due to cirrhosis of the liver. In pure portal cirrhosis the prominent features were distortion of the intrahepatic radicals, pooling of the contrast medium, and numerous collaterals directed superiorly and inferiorly. The collaterals most often seen were those of the left gastric and the paraesophageal veins. The splenic and portal veins were of about normal caliber. In secondary portal cirrhosis following long standing splenomegaly, along with distortion and pooling, the splenic and portal veins were dilated and tortuous.

The fourth pattern was seen in suprahepatic obstruction. In this type the intrahepatic radicles of the portal vein were very prominent and well visualized up to the periphery. There was no distortion of the intrahepatic channels and no evidence of pooling of the contrast medium.

The presence of collaterals in splenoportal venography is a positive indication of portal hypertension and appears earlier than other clinical evidences. The changes in the intrahepatic pattern and the presence of collaterals give an accurate estimate of the presence, as well as the extent, of the fibrotic process of the liver.

Infrahepatic obstruction can be diagnosed with certainty before operation by portal venography alone. The site of obstruction and sometimes its nature can be obtained.

Venographic findings in all these types are of value in planning the proper operative procedure.—*Frank J. Rigos, M.D.*

Süsse, H. J. Gefahren und Technik der Osteomyelographie und transossalen Venographie. (Dangers and technique of osteomyelography and transosseous venography.) *Fortschr. a. d. Geb d. Röntgenstrahlen u. d. Nuklearmedizin*, Aug., 1956, *85*, 181–187. (Address: Universitäts-Röntgeninstitut, Liebigstr. 20a, Leipzig, Germany.)

Although conventional or direct venography is adequate for most investigations of the venous system, osteomyelography and transosseous venography are employed when local edema makes it difficult to locate desired veins and also to gain information concerning venous dynamics as well as the relationship between the osseous and venous

systems. By these methods, many otherwise obscure veins are demonstrable.

Among the dangers of the methods are: (1) Perforation of the aorta through an osteoporotic or otherwise diseased sternum; (2) injection of contrast material into the pleural space when attempting to inject an osteoporotic rib; (3) accidental injection of the spinal canal when examining a spinous process; (4) rupture of the urinary bladder when studying the pubic bones; (5) escape of contrast material into adjacent tissues through the large bore required for these studies and the resultant necrosis; (6) the possibility of introducing infection. None of these complications was experienced by the author in a large number of cases where these methods were used.

The technique is as follows: Each patient is given a sensitivity test either intravenously or subcutaneously, using the contrast material of choice, namely 40–50 per cent ioduron. Aseptic precautions must be taken. General anesthesia is desirable. The needle must be advanced with a straight, steady motion; all sideward movements of the needle are to be avoided; if necessary short strokes with a hammer are used in tougher bones; and rarely, a drill is employed. To be certain that the needle is in the cortex, both blood and fat droplets must be withdrawn prior to injection of contrast material. Use a probe to check whether needle has penetrated through the opposite cortex. This may be further checked by fluoroscopic control, which is certainly advisable after the injection of 1–2 cc. of the contrast substance. When thus assured, inject 20–40 cc. of the material rapidly into the bone. Start serial exposures at onset of injection. Wherever possible passive and active motions of the muscles should be done; massage is to be avoided. Later, roentgenograms are made to check the site for deposition of contrast material and pathologic alteration of the examined bones. All the patients were hospitalized for two to three days.—*J. Zausner, M. D.*

General

Lowman, Robert M., Davis, Leonard, Silver, Henry K., and Nyhan, William. Roentgenographic examination of infants in an incubator; a new device insuring environmental constancy. *Radiology*, Oct., 1956, *67*, 584–586. (Address: R. M. Lowman, Grace-New Haven Community Hospital, 789 Howard Ave., New Haven 4, Conn.)

A simple, inexpensive modification of the standard incubator which overcomes the serious objections to adequate roentgenographic study of ill or delicate infants is described. A plastic radiolucent platform which is raised by ledges approximately 5.5 cm. from the floor of the incubator is introduced for the infant to lie upon. A standard 10 × 12-inch cassette covered by a sterile sheet or pillow slip is introduced beneath the platform when roentgenograms are taken, the incubator hood being lifted only briefly for this purpose. With a small portable oxygen tank in the cabinet portion of the incubator, the infant in this incubator can be wheeled to the radiologic department for examination without interruption of the oxygen supply. The incubator causes no distortion which would interfere with the interpretation of the films.—*Harold C. Hamilton, M.D.*